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PUBLIC SERVICE COMMISSION

OF THE

COMMONWEALTH OF PENNSYLVANIA

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SPECIFICATIONS

COVERING THE CONSTRUCTION AT CROSSINGS OF OVERHEAD LINES OF PUBLIC UTILITIES

GENERAL ORDER NO. 13
Issued—1917

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The Public Service Commission

OF THE

COMMONWEALTH OF PENNSYLVANIA

GENERAL ORDER NO. 13.

In the Matter of the Regulation of the Construction of the Crossing of the Wires of a Public Service Company over or under the Facilities of another Public Service Company.

HARRISBURG, PA.

1917

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PY P9768.8/4 no. 13 1930 c.2
Pennsylvania. Public Service
Commission.
General Order no. 13

THE PUBLIC SERVICE COMMISSION OF THE COMMONWEALTH OF PENNSYLVANIA

WM. D. B. AINEY, Chairman,
JOHN S. RILLING,
WILLIAM A. MAGEE,
MILTON J. BRECHT,
JAMES ALCORN,
MICHAEL J. RYAN,
Commissioners.

A. B. MILLAR, Secretary.

F. HERBERT SNOW,
Chief, Bureau of Engineering.

At a meeting of The Public Service Commission of the Commonwealth of Pennsylvania held at its office in the city of Harrisburg, Pennsylvania, on the 27th day of February, 1917.

GENERAL ORDER NO 13

In the Matter of the Regulation of the Construction of the Crossing of the Wires of a Public Service Company over or under the Facilities of another Public Service Company.

WHEREAS, Under the provisions of Article V, Section 12 of the Public Service Company Law, it is provided that no crossing of the wires of a public service company over or under the facilities of another public service company shall be constructed without the approval of the Commission and also that it shall be proper for the Commission by general rule or order whenever the same can be properly regulated by suitable general rule to prescribe the terms and conditions under which said crossing may be constructed, operated, maintained or protected without the particular approval of the Commission;

And WHEREAS, The Commission by its General Order No. 11 and its Administrative Ruling No. 8, has heretofore adopted certain rules and regulations governing the procedure to be followed in securing the approval of the Commission to such construction, and whereas, after careful investigation the Commission is convinced that the construction of such crossings of the wires of public service companies over or under the facilities of other public service companies can be regulated by general order without the particular approval of the Commission in such a manner as to provide for a construction which will tend to prevent accidents and promote the safety of the public.

NOW, to wit, February 27, 1917, IT IS ORDERED, That from and after the FIRST day of June, 1917, all crossings of the wires of public service companies over or under the facilities of other public service companies shall be made in accordance with the SPECIFICATIONS COVERING THE CONSTRUCTION AT CROSSINGS OF OVERHEAD LINES OF PUBLIC UTILITIES hereto attached.

AND IT IS FURTHER ORDERED, That from and after said first day of June, 1917, such crossings of wires over or under the facilities of other public service companies may be constructed by the companies lawfully authorized so to do in accordance with said specifications without the particular approval of this Commission on condition that notice of said construction specifying the particular point of crossing shall be given to the public service company whose facilities are to be crossed prior to the beginning of the construction of said crossing.

Protest against the construction of any such crossing may be made to the Commission at any time by filing formal complaint which shall set forth the reasons which, in the judgment of the protestant, show that the crossing should not be constructed in accordance with the above mentioned specifications, and proof of service thereof upon the company constructing the crossing shall be filed with the Commission within three days of the filing of the protest with the Commission.

This order supersedes General Order No. 11 and Administrative Ruling No. 8 of this Commission upon the same subject only in so far as said General Order and Ruling relate to the construction above ground of crossings of wires over the facilities of public service companies.

By the Commission,

WM. D. B. AINEY, Chairman.

Attest: A. B. MILLAR, Secretary.

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SPECIFICATIONS COVERING THE CONSTRUCTION AT CROSSINGS OF OVERHEAD LINES OF PUBLIC UTILITIES

INTRODUCTION.

These specifications were prepared at the request of The Public Service Commission and under the direction of its Chief Engineer, F. Herbert Snow, by a Joint Committee representing the different classes of utilities concerned. Said Joint Committee consisted of Paul Spencer of the United Gas and Improvement Company of Philadelphia (Chairman), R. E. Chetwood of the Western Union Telegraph Company, Nathan Hayward of the Bell Telephone Company of Pennsylvania, D. B. Heilman of the Philadelphia and Reading Railway Company, J. S. Jenks of the West Penn Traction Company of Pittsburgh, J. F. Skirrow of the Postal Telegraph-Cable Company, Thomas Sproule of the Philadelphia Electric Company, R. P. Stevens of the Mahoning and Shenango Railway and Light Company of New Castle, Joseph F. Stockwell of the Keystone Telephone Company of Philadelphia, S. M. Veile of the Pennsylvania Railroad Company, G. E. Wendle of the Lycoming Edison Company of Williamsport and J. S. Francis of the Bell Telephone Company of Pennsylvania (Secretary).

In explanation of the specifications, it should be stated that they are intended to cover the crossings of overhead conductors of any utility and the overhead conductors of any other utility, or the tracks and right-of-way of railroads. They are, as far as possible, complete for all types of conductors, and cover definitely the general requirements at the points of crossing, without stating the type of construction in such specific details as to limit it to any particular method.

While the paragraphs are, therefore, necessarily general, and cover conditions and not details of construction, they are believed to be capable of definite interpretations, so as to form the basis of working specifications for the use of the construction men in the field.

The Specifications are divided into nine (9) Sections, as follows:

Section I is general, covering definitions and setting forth classifications.

Section II covers the construction of Power Lines up to 5,000 volts when crossing Communication Circuits, and Power Lines up to 7,500 volts when crossing Power Lines of other Utilities. It also covers the crossing of Communication Lines over other Communication Lines. The various paragraphs in this Section require standard construction, with clearances and separations as specified so as to guard against the possibility of the conductors of any circuit coming in contact with each other, or with the conductors of another line.

Section III covers the construction of Power Lines of over 5,000 volts where crossing over Communication Lines, and of Power Lines of over 7,500 volts where crossing over Power Lines of other Utilities.

Section IV covers "Collinear Construction." By "Collinear Construction" is meant what is generally known as "overbuilding"; that is, the construction of one line parallel with an existing line, but on separate supports, and so placed in reference to it that one line will be wholly or in part over the other. Such construction is considered to be undesirable, as it is difficult to avoid interference between the two lines. In Section IV it is stated that such construction should, so far as practicable, be avoided, but it is recognized that under certain conditions it may be necessary, and the paragraphs of this Section have been included to provide for safe construction when it may be absolutely necessary to build such lines.

Attention is called to the fact that the various paragraphs in Section IV deal only with the questions of safety of construction, and that there are other difficulties in connection with Collinear Construction, or with parallel construction between Power Lines and Communication Lines, which have to do with inductive disturbances, which may affect the service of utilities operating Communication Circuits. The paragraphs in Section IV are not intended to include the construction requirements which might be necessary to remove or limit such disturbances. The Committee felt that the question of inductive interference was beyond the scope of its instructions, as inductive effects are not generally produced by ordinary angle crossings, but are due to parallelism. For the protection of the service of the utility owning the Communication Circuits, it may, therefore, in certain cases be necessary for additional methods of construction than those specified to be employed by the utilities operating the Communication Circuits and the Power Circuits.

Section V covers the construction of Communication Lines where crossing over Railroads, and is based upon the Specifications for Wire Crossings adopted by the Association of Railway Telegraph Superintendent's.

Section VI covers the construction of Power Lines of all voltages where crossing over Railroads. Sections VI and III are practically identical in their provisions, with the exception of the difference in voltage limitations, and with the exception that in Section VI two (2) paragraphs were added; No. 607, to cover the side clearances from the track rails of the Railroad, and No. 608, to cover the vertical clearances above the tracks of the Railroad. With these two (2) exceptions, the various paragraphs in Section VI are identical with similar paragraphs in Section III. It was deemed wise to repeat these paragraphs in Section VI, so as to make the Section complete by itself as applying to crossings over Railroads.

Section VII covers the construction of Overhead Lines where crossing under Railroad Bridges. Its various paragraphs specify the construction to be used where such lines are attached to the under side of bridges. Special consideration has been given to the necessity of providing ample clearance between conductors of high voltage and any portion of the bridge or its abutments, so that there will be sufficient room for inspecting, painting and maintaining the bridge structure.

Section VIII covers underground construction at points of crossing with Railroads. Under special conditions, due to interfering structures or lines of the Railroad, it might be difficult to construct an overhead crossing in accordance with the requirements of Section VI; in such cases, it may be more economical, and for the advantage of all parties in interest, to use underground cable across the Railroad Right-of-Way, connecting this cable at both sides of the right-of-way with the overhead line of which the cable crossing would form a part. Generally, such construction would be undesirable, as the introduction of a short piece of underground cable, as a section of a line elsewhere built as an open wire overhead line, will increase the chance of interruption to, or impairment of, the service of the utility owning the line. A section of underground cable in an overhead line is generally a weak point from the standpoint of service. Such construction should, therefore, be avoided, but Section VIII is included in the Specifications to cover such construction where necessary.

The **Appendices** which are included in **Section IX** are explanatory of the various paragraphs in the different Sections to which they refer. Some of these Appendices include specifications for materials, which are the generally accepted specifications for the material covered. The various tables, such as the tables for sags and for clearances, have been worked out based on the requirements of the paragraphs which cover sags and clearances. They are included for the purpose of reducing the amount of calculation that would be required by any one applying the various paragraphs of the Specifications in construction work. The sketches included in the Appendices are to be considered merely as suggestive, and as illustrating certain methods which can be used to meet the requirements of the various paragraphs to which they refer. They should not be considered as covering the only approved methods of construction to be used in such cases.

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SECTION I.

GENERAL.

SCOPE.

101. Scope. These specifications cover the type of construction to be installed in all cases where the overhead lines of one utility cross over or under the overhead lines of another utility, or over or under the tracks of a railroad.

DEFINITIONS.

102. For the purpose of these specifications certain of the terms used herein are defined as follows:

103. Line. Any aggregation of poles, towers or other supporting structures, together with conductors and other appurtenances carried on such supports.

104. Circuit. Any overhead conductor or combination of conductors which forms a medium or path for the transmission of electrical energy for power or communication purposes.

105. Power Circuit. Any constant potential or constant current circuit used for power, lighting, railway or similar purposes, but not including trolley contact or feeder wires as defined in Paragraphs 111 and 112.

106. Power Line. Any line used mainly for carrying power circuits.

107. Communication Circuit. Any telephone, telegraph or signal circuit not over 750 volts.

108. Communication Line. Any line used mainly for carrying communication circuits.

109. Conductor. Any overhead wire or cable which constitutes part of a power or communication circuit.

110. **Attachment.** Any crossarm, conductor, guard, wire, guy, cable, apparatus, fixture or other appurtenance, which constitutes a part of a line and is carried by any pole, tower, or other support thereof.

111. **Trolley Contact Wire.** Any overhead bare conductor from which, by means of an overhead trolley or similar device, electrical energy is transmitted to moving cars or trains.

112. **Trolley Feeder.** Any conductor used for supplying electrical energy directly to a trolley contact wire at the same voltage.

113. **Crossing Span.** That portion of the conductors of a line between adjacent line supports, which crosses over the conductors of any other line or lines, or the track or tracks of a railroad.

114. **Railroad.** Every railroad and railway other than a street railway, by whatsoever power operated, for public use in the conveyance of passengers or property, or both.

115. **Street Railway.** Every railroad and railway, by whatsoever power operated, for public use in the conveyance of passengers or property, or both, being mainly located upon, over, above, across, through, or along any street, avenue, road, highway, bridge or public place.

116. **Normal.** The conditions existing at a temperature of sixty (60) degrees Fahrenheit, and with no wind or ice loading.

117. **Nominal.** Defines the term, dimension, or value (e. g., diameter, operating voltage, etc.) by which a certain size of material, character of circuit, etc., is commonly known in the art, although the actual term, dimension, or value may vary somewhat from the defined condition.

118. **Collinear.** Defines the condition where one line is built over, under, or along side another line on separate supports (crossings at an angle of fifteen (15) degrees, or over, excepted) so situated that one line is wholly, or partly, over the other line.

119. **Parties in Interest.** A term to be understood as including The Public Service Commission and any other regulating body having jurisdiction and the utilities concerned at the crossing.

CLASSIFICATION.

120. **Classification.** For the purpose of these specifications, circuits or conductors will be designated by class, as follows:

Class		Character and Operating Voltage
A	A-1	Constant potential, alternating current, not grounded, exceeding 5,000 volts and not exceeding 7,500 volts.
	A-2	Constant potential, one side or neutral grounded, exceeding 2,500 volts alternating current to ground, but not exceeding 3,750 volts alternating current to ground, or exceeding 750 volts, nominal, direct current to ground, excepting trolley contact wires.*
	A-3	Constant potential, alternating current, exceeding 7,500 volts between conductors when circuit is not grounded, or exceeding 3,750 volts to ground when circuit is grounded.
B		Constant potential, not exceeding 5,000 volts alternating current, when circuit is not grounded, or not exceeding 2,500 volts alternating current to ground when circuit is grounded, or not exceeding 750 volts, nominal, direct current to ground when circuit is grounded (excepting trolley contact wires*), and constant current series arc or incandescent lighting.

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*Trolley feeders may be classed either with trolley contact wires of corresponding voltage or with other power circuits of the same voltage and character.

Class		Character and Operating Voltage
C		Communication, including telephone, telepraph and signal circuits not exceeding 750 volts, excepting those included in Class **P.**
D	D-1	Trolley contact wires not exceeding 2,500 volts alternating current, or not exceeding 750 volts, nominal, direct current.*
	D-2	Trolley contact wires exceeding 2,500 volts alternating current, or exceeding 750 volts, nominal, direct current.*
P		Telephone, telegraph or other signal wires not exceeding 750 volts used by the owners or operators of Class **A**, Class **B** or Class **D** circuits, but not for the use of the public.

NOTE:—Where Class **P** circuits throughout are in conformity with the requirements of these specifications for Class **C** circuits, the Class **P** conductors in the crossing span shall be treated as Class **C.**

Where Class **P** circuits throughout are not in conformity with the requirements of these specifications for Class **C** circuits, the crossing span shall be so constructed that the degree of hazard shall not be materially increased due to the presence of Class **P** circuits.

121. **Changes at Crossing.** When the operating voltage of the power circuits at a crossing is to be changed, the construction at the crossing shall be changed, if necessary, to conform with these specifications.

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*Trolley feeders may be classed either with trolley contact wires of corresponding voltage or with other power circuits of the same voltage and character.

SECTION II.

SPECIFICATIONS FOR THE CONSTRUCTION OF OVERHEAD CROSSINGS OF LINES OF LOWER VOLTAGE.

SCOPE.

201. **Scope.** These specifications apply to crossings, as follows:

Class **A-1** cross over Class A-1, A-2, B, D.
Class **A-2** " " " A-1, A-2, B, D.
Class **B** " " " A-1, A-2, B, C, D.
Class **C** " " " B, C, D-1 (not over D-2).
Class **D** " " " D.

It is not intended that this section apply to cases where Class B wires cross over Class C and Class D-2 in the same span; crossings of this nature shall be constructed in accordance with Section III.

It is not intended that these specifications apply to crossings over or under individual twisted pair drop wires, service wires, or other circuits of minor importance, where equally effective protection may be secured more economically by other methods of construction.

202. **Positions at Crossings.** At crossings, conductors should generally be arranged in the order of the operating voltage, conductors of greatest voltage occupying the highest position, with the exception of trolley contact wires, which must necessarily occupy the lowest position, and trolley feeders which, for practical purposes, are generally run in approximately the same horizontal plane as the trolley contact wires to which they connect.

In crossing over trolley wires and feeders, or where it is impracticable to have the higher voltage wires above, the conductors occupying the upper position shall be considered, insofar as mechanical strength of construction is concerned, as included in the class of power circuits of the highest voltage below them.

203. **Length of Span.** The length of the crossing span should preferably not exceed 150 feet.

204. **Clearance of Conductors.** The vertical clearance, under normal conditions, between conductors of the crossing span and conductors of the span crossed, where carried on separate poles, shall not be less than two (2) feet for power conductors crossing other power conductors, and not less than four (4) feet for power conductors crossing over or under communication conductors.

(a) The minimum clearance, as given above, shall be increased by two (2) inches for each ten (10) feet in excess of fifty (50) feet of the total distance obtained by adding together the distance from the point of crossing to the nearest pole supporting the crossing span, and the distance from the point of crossing to the nearest pole supporting the span crossed.

(b) Where conductors of Class **C** only are involved, and there are no conductors of any other class in either crossing span or span crossed, the minimum vertical clearance shall be two (2) feet Where cables or twisted pair wires, only, are used on one or both of the two lines, this clearance may be reduced to one (1) foot.

(c) Where conductors of Class **D** are involved, the conductors of the crossing span shall be sufficiently raised above Class **D** wires, or otherwise protected to guard against damage from contact with trolley poles which may leave the trolley contact wire.

(d) As trolley contact wires of necessity cross at the same level, arrangements must be made to provide an insulating cross-over, unless a conducting cross-over is agreed to by all the parties in interest.

205. **Clearance of Poles.** The poles of the line making a crossing shall be so located that no interference with the existing lines, or with the free use of the poles of either line, shall result.

206. Spacing of Conductors. The minimum separation in any direction, at the points of support, for power conductors or trolley feeders carrying a difference of potential, when supported on pin type insulators, shall be one (1) inch for each twenty (20) feet of span and one (1) inch additional for each foot of normal sag; but in no case shall the separation be less than twelve (12) inches, except that trolley feeders and ground returns 4/0 or larger, from 0-750 volts, may have a minimum separation of not less than six (6) inches, and signal wires may have a minimum separation of six (6) inches, which may be still further reduced at transpositions.

Where supported by insulators of the disc or suspension type, the minimum separation of conductors figured as above shall be increased by twenty-five (25) per cent., unless dead-ended or otherwise prevented from swinging.

The separation between conductors with voltages less than 750, carried on secondary racks bolted to the pole, may be not less than three (3) inches.

NOTE:—The separations specified in this paragraph do not apply to pole wiring.

207. Climbing Space. Power conductors of all classes shall be so installed as to provide a clear climbing space adjacent to the pole to which they are attached of not less than thirty (30) inches. This climbing space may be entirely on one side of the pole where necessary due to the use of cables or secondary rack construction carried on the other side of the pole. Conductors of communication circuits, where installed below power conductors and attached to the same pole, shall be so installed as to provide a similar climbing space.

208. Conductors. Conductors shall be of copper copper-covered steel, aluminum, galvanized steel or other corrosion-resisting material.

209. Size of Conductors. Copper conductors of the crossing span shall not be smaller than the sizes given in the following table:

CLASS OF CONDUCTORS INVOLVED	SIZE OF WIRE—AMERICAN WIRE GAUGE			
	Line Spans		Service Spans	
	Soft Drawn	Hard Drawn	Soft Drawn	Hard Drawn
A	6	..	..	..
B	6	10	8	14
C	..	14	..	14

NOTE:—In using the above table, the highest voltage of any conductor, in either the crossing span or the span crossed, shall be used in order to determine the class of conductors involved.

No twisted pair wire of smaller conductor size than No. 14 A. W. G. copper or No. 17 A. W. G. copper-covered steel, or its equivalent in strength, shall be used in the crossing span.

Conductors of material other than copper, and messenger wires, shall be of such size and so erected as to have a mechanical strength not less than that of the sizes of copper conductors given above; but in no case shall the tensile strength of messenger wire, carrying cable or twisted pair wires, be less than 2,300 pounds.

210. **Sag of Conductors.** At crossings where power circuits are involved, conductors of the crossing span shall be strung with sags not less than shown in the tables given in Appendix A.

NOTE:—Where conductors of Class **C** only are involved, and there are no conductors of any other class in either crossing span or span crossed, the provisions of this paragraph do not apply.

211. **Conductor Fastenings.** Insulators, pins and conductor fastenings shall provide mechanical strength not less than the tension in the conductors supported, except where this is greater than 1,000 pounds, when the strength shall be at least 1,000 pounds.

212. **Crossarms.** Wooden crossarms carrying the crossing span shall be of long-leaf yellow pine, fir or other suitable timber and shall have a minimum section of three (3) inches by four and one-quarter (4¼) inches. Galvanized or painted iron, or steel crossarms, of equal strength may be used.

213. Crossarms carrying the crossing span shall be attached to the poles with through bolts and shall be equipped with suitable galvanized iron braces.

214. **Gain Spacing.** The standard gain spacing between cross-arms (buck-arms excepted), shall be twenty-four (24) inches.

215. **Galvanizing.** Galvanized material shall meet the requirements specified by the National Electric Light Association or other standard generally sanctioned by good modern practice.

Sherardizing of small parts is permitted.

All holes in galvanized material shall be made before galvanizing.

216. **Poles.** Wooden poles supporting the crossing span shall be of chestnut or other selected timber, and shall be sound and reasonably straight.

Iron, steel or reinforced concrete poles, of adequate strength, may be used.

(For specifications for wooden poles, see Appendix B).

217. **Permissible Pole Loading.** Wooden poles supporting the crossing span shall carry not more than the number of No. 4 weather-proof wires specified in the tables in Appendix L or an equivalent load, excepting when the poles are guyed in accordance with Paragraph 220.

218. **Pole Setting.** Poles supporting the crossing span shall be set in ground to depths not less than those shown in the following tabulation:

Total Length of Pole (Feet)	Depth in Earth (Feet)
20	4.0
25	5.0
30	5.0
35	5.5
40	6.0
45	6.5
50	6.5
55	7.0
60	7.5
65	8.0
70	8.0
75	8.5
80	8.5

When the poles are set in rock, the depth of the setting may be decreased depending upon its character, but this depth shall never be less than three and one-half (3½) feet.

219. **Identification.** For the purpose of identification, poles or structures supporting the crossing span shall be clearly marked with the name, initials, or trade-mark of the owner of the structure.

220. **Guying.** The line of which the crossing span is a part shall be guyed according to the best modern practice.

Where head guys are installed on poles supporting the crossing span, they shall be so installed as not to increase appreciably the stress in the conductors of the crossing span.

The tensile strength of guys shall not be less than 2,300 pounds.

Poles supporting the crossing span shall be side and head-guyed when the loads are in excess of those specified in Paragraph 217.

The number and arrangement of guys shall be determined by the conditions existing at the crossing. Braces may be used instead of guys. Where poles, not self-supporting, are guyed, they become rigid structures acting only as struts, and the horizontal component of the load will be considered as taken entirely by the guys.

221. **Clearance of Guys.** The clearance between guy wires of one line and conductors of another line shall, where practicable, be not less than three (3) feet.

222. **Guy Anchorage.** Guys to ground shall be connected to a well anchored rod of such length that the eye of the rod shall be above the surface of the ground. Rods with a diameter of less than one (1) inch shall be galvanized.

223. Guy anchors shall, where practicable, be placed at a horizontal distance from the poles they reinforce, measured at the ground line, of not less than one-third (1/3) of the height of the point of attachment of the guy to the pole.

224. **Guy Strain Insulators.** Strain insulators shall be placed in all guys in the proximity of crossings where power circuits are involved, or these guys shall be permanently and effectually grounded. Strain insulators, in general, shall be placed not less than six (6) feet below the lowest conductor, not less than eight (8) feet above the ground, and, where practicable, not less than six (6) feet in a horizontal direction from the pole. Where it is impracticable to comply with the provisions of Paragraph 221, strain insulators shall be so placed as to protect pedestrians and men working on either line.

Strain insulators, when used in guys, shall meet the following mechanical and electrical requirements:

(a) Strain insulators shall be capable of withstanding the maximum mechanical stress to which the guy of which they are a part may be subjected.

(b) Strain insulators installed in guys shall be capable of withstanding, without puncture or flash-over, the maximum line voltage carried on either pole to which the guy is attached.

225. **Other Construction Requirements.** Construction requirements for all crossings, where not covered by these specifications, shall be according to the best modern practice.

226. For cause shown, in special cases, the Commission may afford relief from the operation of these Regulations to any particular public utility when public convenience and safety will not be injuriously affected thereby, and the welfare of such public utility will be subserved by modifications of any of the foregoing Regulations and Specifications.

SECTION III.

SPECIFICATIONS FOR THE CONSTRUCTION OF OVERHEAD CROSSINGS OF LINES OF HIGHER VOLTAGE.

SCOPE.

301. These specifications apply to crossings as follows:

(a) All Class **A-3** crossing spans;
(b) Class **A** over Class **C**;
(c) Class **A** or Class **B** over Class **A-3**;
(d) In respect to mechanical requirements Class **C** over Class **A** or Class **D-2**;
(e) Class **B** over Class **C** and Class **D-2** in the same span.

It is not intended that these specifications apply to crossings over individual twisted pair drop wires, service wires, or other circuits of minor importance where equally effective protection may be secured more economically by other methods of construction.

GENERAL.

302. **Positions at Crossings.** At crossings, conductors should generally be arranged in the order of the operating voltage, conductors of greatest voltage occupying the highest position, with the exception of trolley contact wires, which must necessarily occupy the lowest position, and trolley feeders which, for practical purposes, are generally run in approximately the same horizontal plane as the trolley contact wires to which they connect.

In crossing over trolley wires and feeders, or where it is impracticable to have the higher voltage wires above, the conductors occupying the upper position shall be considered, insofar as mechanical strength of construction is concerned, as included in the class of power circuits of the highest voltage below them.

303. Location of Poles. The poles or towers supporting the crossing span and the next adjoining spans, where practicable, shall be located in a straight line.

304. Falling Trees. The crossing span and the next adjoining spans, so far as practicable, shall be kept free from trees which might fall into the line.

305. Fire Hazard. The poles or towers of the crossing span, so far as practicable, shall be located away from inflammable material or structures.

306. Length of Span. The length of the crossing span, where practicable, shall be not greater than the normal span of the line, and the length of the next adjoining span, where practicable, shall be not greater than one and one-half ($1\frac{1}{2}$) times the length of the normal span.

CLEARANCES.

307. Overhead Clearance. The vertical clearance between conductors of the crossing span and conductors of the span crossed, where carried on separate poles, shall be, under normal conditions (sixty (60) degrees Fahrenheit, and no wind or ice loading), not less than the sum of the values of (a) and (b) determined as below, but in no case where voltage is more than 7,500, less than six (6) feet.

(a) One-tenth (1/10) of a foot for each kilo-volt, with a minimum value of four (4) feet.

(b) Two (2) inches for each ten (10) feet of the total distance obtained by adding together the distance from the point of crossing to the nearest pole supporting the crossing span, and the distance from the point of crossing to the nearest pole supporting the span crossed.

NOTE:—Where conductors of Class **D-2** are involved, the conductors of the crossing span shall be sufficiently raised above Class **D-2** wires, or otherwise protected to guard against damage from contact with trolley poles which may leave the trolley contact wires.

308. Clearance of Poles. The poles of the line making a crossing shall be so located that no interference with the existing lines, or with the free use of the poles of either line, shall result.

309. Clearance of Guys. The clearance, under normal conditions, between conductors of one line and guy wires of another line, where practicable, shall be not less than one-tenth (1/10) foot for each kilo-volt with a minimum of four (4) feet.

310. Spacing of Conductors. The minimum separation in any direction, at the points of support, for power conductors carrying a difference of potential and supported on pin type insulators, shall be one (1) inch for each twenty (20) feet of span, and one (1) inch additional for each foot of normal sag, but in no case shall the separation be less than that shown in the following table:

VOLTAGE BETWEEN CONDUCTORS		
Exceeding	Not Exceeding	Separation
	7,000	12 in
7,000	14,000	20 in.
14,000	27,000	30 in.
27,000	35,000	36 in.
35,000	47,000	45 in.
47,000	70,000	60 in.
70,000		60 in. plus 0.6 in. per k.v. in excess of 70.

Where supported by insulators of the disc or suspension type, the minimum separation of conductors shall be increased by twenty-five (25) per cent., unless dead-ended or otherwise prevented from swinging.

NOTE:—The separations specified in this paragraph do not apply to pole wiring.

311. Clearance between Conductors and Supports. Clearance between any power conductor, or live hardware, and any portion of the supporting structure (insulator pins not included) shall not be less than three (3) inches, plus twenty-five one-hundredths (0.25) of an inch for each kilo-volt in excess of seven (7). For conductors supported by suspension or disc type insulators and not dead ended at the pole structure, or otherwise prevented from swinging, clearance as above shall be figured on the assumption that the maximum deflection of the supporting insulators is forty-five (45) degrees from the vertical.

312. Gain Spacing. In no case shall the gain spacing between crossarms (buck arms excepted) be less than twenty-four (24) inches.

CONDUCTORS.

313. Material of Conductors. Conductors shall be of copper, copper-covered steel, aluminum, galvanized steel, or other corrosion resisting material, provided, however, that galvanized steel shall not be used in localities subject to excessive coal gases, or other conditions which would cause unusual corrosion.

314. Size of Conductors. The minimum allowable sizes for conductors of the crossing and adjoining spans are as follows:

Copper or Copper-covered Steel	
Spans less than 150 feet.	No. 6 Am. Wire Guage
Spans 150 feet and over	No. 4 “ “ “
Aluminum	No. 1 “ “ “
Galvanized Steel	5/16 inch diameter

315. All aluminum and galvanized steel conductors shall be stranded.

NOTE:—The information available at present is not sufficient to show conclusively the relative reliability of stranded and solid copper conductors. Information is being collected on this subject and, until these data are available, no requirement as to the use of stranded or solid copper conductors is considered advisable.

316. Sag of Conductors. Conductors of the crossing and adjoining spans shall be strung with at least such sags as to withstand, with the designated factor of safety (Paragraph 359), the stresses due to the specified loading (Paragraph 356). See Appendix C for table of sags.

317. **Splices in Conductors.** The conductors in the crossing span shall be free from splices or taps. If a splice or tap is employed in any conductor in the next adjoining span, it shall be placed at a point nearer the crossing support than the distance from the crossing support of that conductor to the nearest wire crossed.

NOTE:—Where crossing is made under existing wires, the above requirement regarding splices may be waived with the consent of all parties in interest.

LIGHTNING PROTECTION WIRES.

318. **Lightning Protection Wires.** Lightning protection wires or cables, if used, shall conform to the requirements of specifications for conductors (Paragraphs 313, 314, 315, 316 and 317). When such wires are not connected to thoroughly grounded steel structures, they shall be permanently connected to ground, at each crossing pole or tower, by a wire with a conductivity not less than No. 4 A. W. G. copper. The ground wire shall be connected directly to the lightning protection wire and to a well-made ground, and the course of this ground connection shall be as straight as possible.

INSULATORS.

319. **Material of Insulators.** Insulators on power lines shall be of porcelain, or other material, which can be shown, to the satisfaction of the parties in interest, to be equally good in respect to mechanical and electrical requirements and durability.

320. **Design of Insulators.** Insulators shall be so designed that their dry flash-over is not more than seventy-five (75) per cent. of their puncture voltage, at a frequency of sixty (60) cycles.

321. **Factor of Safety of Insulators.** Insulators supporting the crossing and adjoining spans shall be capable of withstanding, without flash-over, at a frequency of sixty (60) cycles, the normal circuit voltage multiplied by the following factors:

VOLTAGE OF CIRCUIT		FACTOR	
Exceeding	Not Exceeding	Dry	Wet
	9,000	6.0	4.0
9,000	14,000	5.3	3.5
14,000	27,000	4.5	3.0
27,000	35,000	3.9	2.6
35,000	47,000	3.6	2.4
47,000	60,000	3.3	2.2
60,000		3.0	2.0

By the term "wet' is meant a condition equivalent to a precipitation of one-fifth (1/5) inch of rain per minute at an angle of forty-five (45) degrees to the axis of the insulator.

322. **Tests.** Each completed pin type insulator for line voltages over 15,000, and each completed suspension insulator disc, shall be subjected to a routine factory test at dry flash-over voltage, at a frequency of sixty (60) cycles for five (5) consecutive minutes, or any other test which may be generally sanctioned by good modern practice.

323. **Voltage Measurements.** Test voltages shall be determined by methods conforming to the standards of the American Institute of Electrical Engineers.

324. **Strain Insulators.** Strain insulators, when used in guys, shall meet the following mechanical and electrical requirements:

(a) Strain insulators shall be capable of withstanding the maximum mechanical stress to which the guy of which they are a part may be subjected, with the factors of safety given in Paragraph 359.

(b) Strain insulators installed in guys shall be capable of withstanding, without puncture or flash-over, twice the maximum line voltage carried on either pole to which the guy is attached.

CONDUCTOR ATTACHMENTS.

325. **Pins.** Insulator pins shall be of steel, wrought iron or malleable iron, and shall be galvanized. Cast-iron pin bases may be used. Pins of locust wood may be used, provided con-

ditions are such that digestion or rapid deterioration of wood pins does not occur.

326. Strength of Pins, Insulators and Fastenings. Insulators, pins and conductor fastenings (including clamps, ties and dead ends), carrying the crossing span, shall be designed:

(a) To withstand, with the designated factors of safety (Paragraph 359), the stresses produced by the conductor under the specified loading (Paragraph 356).

(b) To withstand, with the designated factors of safety (Paragraph 359), the stress due to the pull in one direction of the conductor supported,—the pull being taken as the tension in the conductor due to the specified load (Paragraph 356).

A longitudinal movement of the conductor will be permitted, provided this movement will not reduce the designated clearance at the point of crossing (Paragraph 307) by more than twenty-five (25) per cent. In the calculation of stress, no allowance shall be made for deformation, deflection or displacement of any part of the structure.

Method of Attaching Conductors to Insulators. When the stress in the conductor, under the specified loading (Paragraph 356,) does not exceed 2,000 pounds, the method of attaching conductors to double pin type insulators by tie wires, as shown in Appendix D, Figure 1, may be used to meet the requirements of this paragraph.

When the stress in the conductor, under the specified loading (Paragraph 356), exceeds 2,000 pounds, or when conditions are such that suspension or disc type insulators are desirable, a method of attaching conductors, satisfactory to all parties in interest, shall be used.

For suggested methods, see Appendix D.

327. Special Protection at Insulator. Where metal pins are used at either of the two crossing supports, or where wood pins are used and the crossarms are grounded (wood pins and non-grounded construction being generally used in other parts of the line), the insulators used on such metal or grounded supports shall have an electrical factor of safety fifty (50) per cent. greater than at other parts of the line, but in no case less than as specified in Paragraph 321.

As an alternative, the conductors, at their points of attachment to the insulators at the crossing span, may be protected by arcing shields as shown in Appendix D.

NOTE:—The purpose of the foregoing requirements, described in Paragraphs 326 and 327, is to guard against the failure of the construction due to any of the following accidental conditions:

I. Mechanical Failures.

- **(a)** Failure due to the stresses produced by the conductors under the specified loading (Paragraph 356).
- **(b)** Failure due to unbalanced stresses in conductors, resulting from conductor, insulator, pin, or conductor fastening failing at the adjoining pole or tower.
- **(c)** Failure due to a broken or damaged insulator.

II. Electrical Failures.

- **(a)** Burning, by arcs or leakage current due to the failure of an insulator, pin, or conductor fastening, of any wooden part of the supporting structure which, if burned, would render the conductor liable to fall.
- **(b)** Burning or weakening of the conductor, at the insulator, due to arcs or leakage current.

Other methods of guarding against these accidental conditions may be used, if agreed upon by the parties in interest, as being equally effective as the methods herein described.

CROSSARMS.

328. Crossarms. The crossarms carrying the crossing span shall be of at least the following dimensions:

(a) Wood crossarm—3½ in. x 4½ in.
(b) Steel " —3 in. x 3 in. x 5/16 in.

329. Crossarms carrying the crossing span shall be attached to the poles with through bolts and shall be equipped with suitable galvanized iron braces. Double crossarms shall be fitted with spacing bolts, equipped with spacing nuts and washers, pipe spacers, or similar construction, or with spacing blocks or plates.

330. Strength of Crossarms. The crossarms carrying the crossing span, including their fastenings to the poles or towers, shall be designed:

(a) To withstand, with the designated factors of safety (Paragraph 359), the stresses produced by the conductors under the specified loading (Paragraph 356).

(b) To withstand, at all times without failure, the unbalanced stress due to the combined pull in one direction of all the conductors supported,—the pull of each conductor being taken as the tension in the conductor due to the specified load (Paragraph 356).

In the calculation of stress, no allowance shall be made for the deformation, deflection or displacement of any part of the structure.

For method of figuring strength of double crossarms, see Appendix E.

SUPPORTING STRUCTURES.

331. Wooden Poles. Wooden poles supporting the crossing span shall be of chestnut or other selected timber, reasonably straight, peeled, free from defects which decrease their strength or durability, and not less than twenty-two (22) inches in circumference at the top.

332. Steel Towers. Steel for structures supporting the crossing span shall conform to the "Specifications for Structural Steel for Buildings," as adopted by the American Society for Testing Materials.

333. Design and workmanship shall be in accordance with good modern practice.

334. The form of the frame shall be such that stresses may be computed with reasonable accuracy, or the strength of the structure shall be determined by actual test.

335. Construction shall be such that all parts are accessible for inspection, cleaning and painting, and shall not permit of pockets in which water or dirt might collect.

336. The unsupported length of a tower leg shall not exceed 140 times its least radius of gyration.

The unsupported length of a secondary compression member, having figured stress, shall not exceed 180 times its least radius of gyration.

The unsupported length of a compression member, placed to reduce the unsupported length of a leg or secondary member (therefore having no figured stress), shall not exceed 200 times its least radius of gyration.

337. The minimum thickness of metal in galvanized structures shall be one-quarter ($\frac{1}{4}$) inch for main members and three-sixteenths (3/16) inch for all other members. The minimum thickness of metal in painted structures shall be one-quarter ($\frac{1}{4}$) inch.

338. Strength of Supporting Structures. The poles or towers supporting the crossing span shall be designed:

(a) To withstand, with the designated factor of safety (Paragraph 359), the combined stresses produced by their own weight, the specified wind pressure on the poles or towers (Paragraph 357), and the specified conductor loading (Paragraph 356) on all conductors supported in both the crossing span and the next adjoining span.

(b) To withstand, at all times without failure, the unbalanced stress due to the combined pull in the direction of the crossing of all the conductors supported,—the pull of each conductor being taken as the tension in the conductor due to the specified load (Paragraph 356).

NOTE:—In designing steel towers, to withstand this unbalanced stress, the maximum allowable unit fibre stress shall be:

For tension members: 24,000 lbs. per square inch.

For compression members: $24{,}000 - \frac{60L}{R}$ lbs. per square inch.

In the case of wooden or steel poles, when head guys are used to meet this requirement, this unbalanced stress may be assumed to be distributed equally over one or more poles adjoining the crossing, provided all the construction between the crossing span and any such poles is in conformity with these specifications.

In the calculation of stress, no allowance shall be made for the deformation, deflection or displacement of any part of the structure.

339. In the case of wooden pole construction, where the requirements of Paragraph 338 (a) cannot be met except by the use of side guys or special structures, and it is physically impracticable to employ side guys at the crossing poles, the requirements of Paragraph 338 (a) may be met by side-guying the line as near as practicable to the crossing but at a distance not exceeding 500 feet from the point of crossing, provided:

(a) The side-guyed poles shall be designed to withstand the stress due to wind and ice loading transversely to the line, on the assumption that the whole transverse strain of the line, between the poles so side-guyed, is carried by them.

(b) The line between such guyed poles and the crossing shall be substantially in a straight line with the crossing poles.

(c) The average length of span between the guyed poles and the crossing shall not be in excess of 150 feet.

When these conditions are met, and the crossing line between the guyed poles is otherwise constructed in accordance with these specifications, then, for the intervening poles, considered individually, without reinforcement from adjoining poles, the requirements of Paragraph 338 (a) may be modified to the extent of reducing the specified factor of safety, depending upon the number of wires carried, as per the following table:

Number of Wires	Factor of Safety
4	4.0
6	3.5
12	2.0
18	1.4
24 or more	1.0

340. **Pole Setting.** Poles shall be set in the ground to depths not less than those shown in the following tabulation:

Total Length of Pole (Feet)	Depth in Earth (Feet)
25	5.5
30	6.0
35	6.0
40	6.5
45	7.0
50	7.0
55	7.5
60	7.5
65	8.0
70	8.0
75	8.5
80	8.5

When poles are set in rock, the depth of the setting may be decreased, depending upon its character, but this depth shall never be less than four (4) feet.

341. Where located in soft or swampy ground, the setting of poles shall be suitably reinforced. This may be done by setting in barrels of broken stone or gravel, or in stone or timber footings, or by any other equally effective method.

342. Where located in the sides of banks, or where subject to washouts, foundations or pole settings shall be given additional depth, or be protected by cribbing or riprap.

343. Backfillings for foundations or pole settings shall be carefully tamped, or otherwise thoroughly compacted, while being placed.

344. **Foundations for Steel Towers.** Foundations for towers supporting the crossing span shall be adequate to withstand, with the designated factor of safety (Paragraph 359), the maximum stress to which they will be subjected when wires and structures are loaded in accordance with Paragraphs 338, 356 and 357.

345. In designing foundations for towers, the weight of concrete shall be considered as 140 pounds per cubic foot. The weight of "earth" (calculated at thirty (30) degrees from the vertical) shall be considered, in good ground, as 100 pounds per cubic foot. In swampy ground, special measures shall be taken to prevent uplift or depression.

346. The top of a concrete foundation, or casing, shall extend at least six (6) inches above the surface of the ground, except when pavements or sidewalks make this impracticable, and shall have sufficient slope to prevent collection of water.

347. **Identification.** For the purpose of identification, poles or structures supporting the crossing span shall be clearly marked with the name, initials, or trade-mark of the owner of the structure.

GUYS.

348. **Use of Guys.** Guys may be used in meeting the specified strength requirements for supports (Paragraph 338). The number and arrangement of guys shall be determined by the conditions existing at the crossing. Braces may be used instead of guys. Where head guys are installed on poles supporting the crossing span, they shall be so installed as not to increase appreciably the stress in the conductors of the crossing span.

349. Where poles, not self-supporting, are guyed, they become rigid structures acting only as struts, and the horizontal component of the load will be considered as taken entirely by the guys. Where steel structures, not self-supporting, are guyed, they act as struts and also as beams. In figuring the strength of such structures and their guys, the structures con-

sidered alone, may be figured as carrying such portion of the horizontal component of the load, together with the vertical component of the load acting on the structure as a strut, as will not stress any part of the structure beyond the designated factor of safety (Paragraph 359). The remaining portion of the horizontal component of the load shall be figured as carried by the guys with the designated factor of safety (Paragraph 359).

350. **Material.** Guys shall be galvanized or copper covered stranded steel cable, or rolled rods, and must have a minimum nominal diameter of five-sixteenths (5/16) inch.

351. **Anchorage.** Guys to ground shall be connected to a well-anchored rod of such length that the eye of the rod shall be above the surface of the ground. Rods with a diameter of less than one (1) inch shall be galvanized.

352. Guy anchors shall, when practicable, be placed at a horizontal distance from the poles they reinforce, measured at the ground line, of not less than one-third (1/3) of the height of the point of attachment of the guy to the pole.

353. **Guy Stubs.** Guy stubs, or poles used as guy stubs, with their foundations, anchorages and reinforcements, shall be adequate to withstand, with the designated factor of safety (Paragraph 359), the maximum stress to which they will be subjected when wires and structures are loaded in accordance with Paragraphs 338, 356 and 357.

354. **Strain Insulators.** A strain insulator, when used, shall conform to requirements of Paragraph 324, and in general shall be placed not less than six (6) feet below the lowest conductor, not less than eight (8) feet above the ground, and, where practicable, not less than six (6) feet, in a horizontal direction, from the pole. When it is impracticable to comply with the provisions of Paragraph 309, strain insulators shall be so placed as to protect pedestrians and men working on either line. Guys not equipped with strain insulators shall be permanently and effectually grounded.

PROTECTIVE COATINGS.

355. Protective Coatings on Steel. All structural steel shall be thoroughly cleaned at the shop, and shall be galvanized or painted, as follows:

(a) Painting. Painting shall consist of one (1) complete shop coat, one (1) field coat on all contact surfaces before assembling, and one (1) complete field coat after assembling. Before painting in the field, the surface of the metal shall again be thoroughly cleaned of all dirt, grease, etc., and worn or defaced spots shall be touched up. No painting shall be done in freezing or rainy weather.

(b) Galvanizing. Galvanized material shall meet the requirements specified by the National Electric Light Association, or other standard generally sanctioned by good modern practice.

Sherardizing of small parts is permitted.

All holes in galvanized material shall be made before galvanizing.

LOADS.

356. Loads. The conductors shall be considered as loaded uniformly throughout their length with a load equivalent to the resultant of the dead load, the weight of a layer of ice one-half ($\frac{1}{2}$) inch in thickness, and a wind pressure of eight (8) pounds per square foot of ice-covered diameter, at a temperature of zero (0) degrees Fahrenheit. The weight of the ice shall be assumed as fifty-seven (57) pounds per cubic foot (0.033 pounds per cubic inch).

357. The supporting structures shall be considered as subjected to a wind pressure of:—

(a) Eight (8) pounds per square foot on the projected area of cylindrical surfaces, such as wood or tubular steel poles.

(b) Thirteen (13) pounds per square foot on the projected area of flat surfaces, such as crossarms, etc.

(c) Thirteen (13) pounds per square foot on twice the projected area of one of two parallel faces of latticed or trussed structures.

The areas above enumerated shall be considered as increased by one-half (½) inch of ice on all the exposed surface.

358. **Temperatures.** Computation of stresses due to the temperature load shall be based upon an assumed temperature of minus twenty (—20) degrees Fahrenheit.

GENERAL REQUIREMENTS.

359. **Mechanical Factors of Safety.** In design and construction the ultimate unit strength divided by the allowable working unit stress shall be not less than the values shown in the following tabulation:

Wires, cables and conductor attachments, ...	2
Pins, ...	2
Pole line hardware, ...	2
Line insulators (mechanical), ...	3
Guy insulators—non-interlocking, ...	3
Guy insulators—interlocking, ...	2
Guys, ...	3
Wooden poles, ...	4
Wooden crossarms, ...	4
Structural steel poles, towers and crossarms, ...	3
Reinforced concrete poles and crossarms, ...	4
Foundations and anchorages, ...	2

Allowable working unit stresses, as given in Appendix F, are derived by dividing generally approved ultimate unit strengths by the factors of safety shown above.

360. **Other Construction Requirements.** Construction requirements for all crossings, where not covered by these specifications, shall be according to the best modern practice.

ALTERNATE TYPES OF CONSTRUCTION.

361. The following describes methods of construction which offer alternatives to some of the foregoing requirements. Un-

less specifically excepted all the foregoing requirements will apply to these types of construction.

362. **Short Span Method.** This method consists in making a short span at such a height that the radial distance, from the lowest insulators of the crossing span to the nearest wires of the span crossed, is greater than the length of the crossing span.

Conductors not meeting the requirements of Paragraphs 313 to 317, inclusive, may be used, provided a grounded guard arm is placed on each of the crossing poles or towers in such a manner as to prevent the upper wires in the next adjoining spans from whipping back into the wires crossed in case of failure of the upper wires. The requirements which may be omitted when this construction is used are Paragraphs 306, 313 to 317, inclusive, and 319 to 323, inclusive.

If conductors, which meet the requirements of Paragraphs 313 to 317, inclusive, are used, and the next adjoining spans to the crossing are not less in length than twice the height above ground of the highest wire of the crossing spans, the grounded guard arms may be omitted.

To avoid the necessity for poles or towers of excessive height, as supports for the crossing span:

(a) The line crossed shall be built as low as possible.

(b) On Class C lines so crossed, the horizontal distance between conductors may be reduced to permit the crossing poles or towers to be placed nearer together.

See Appendix G.

363. **Use of Cable.** The Class A wires may be carried in aerial, armored, or metal sheath cable, in which case the requirements of the following paragraphs may be omitted:

307, 310 to 312, inclusive
319 to 323, inclusive
325, 326 and 327.

The vertical clearance from the cable to any conductor of the span crossed shall be not less than forty (40) inches.

The provisions of Paragraphs 313, 314, 315, 316 and 317 shall apply to the supporting messenger wire, but not to the cable or cable conductors.

The provisions of Paragraphs 328, 329 and 330 shall apply where cable is suspended from crossarms and not otherwise.

The messenger and armor or metal sheath of the cable shall be permanently and effectually grounded. The cable shall extend at least one span on each side of the crossing. The cable shall be capable of withstanding at least twice the normal line voltage between any two conductors, or between any conductor and the sheath or armor.

364. For cause shown, in special cases, the Commission may afford relief from the operation of these Regulations to any particular public utility when public convenience and safety will not be injuriously affected thereby, and the welfare of such public utility will be subserved by modifications of any of the foregoing Regulations and Specifications.

SECTION IV.

SPECIFICATIONS FOR COLLINEAR CONSTRUCTION OF OVERHEAD LINES.

401. Definition. The term "conflicting construction" shall be understood to mean a situation where a line is built over, under, or alongside another line, on separate supports (crossings at an angle of fifteen (15) degrees or over excepted) within such distance that failure of the supports or attachments of one line might result in contact with the attachments of the other line. When the conflicting lines are so situated that one line is wholly or partly over the other line, the construction will be designated as "collinear."

402. Scope. While the scope of these specifications does not include provisions covering conflicting lines generally, it does include collinear construction, and, as Sections II and III are primarily confined to angle crossings, the requirements pertaining to collinear lines are given below.

403. Notice of Construction. So far as practicable, collinear construction shall be avoided except where joint construction is employed. No company shall construct a line collinear with any existing line without first giving the owner of the existing line notice, in writing, sufficiently in advance to afford opportunity for consideration by the interested companies of means for avoiding the collinear condition.

404. Conditions. When conditions are such that avoidance of collinear construction is impracticable, the line may be built subject to the following conditions:

(a) In case of collinear construction between Class **B** and Class **C** lines, Class **B** lines shall, where possible, occupy the upper position and shall conform to the requirements of Section II of these specifications, except as modified by the following:

(i) The clearance between the top wire of the lower line and the bottom wire of the upper line shall not be less than forty (40) inches, plus two (2) inches for each ten (10) feet in length of the span of the upper line in excess of one hundred (100) feet.

(ii) The construction of the line in the lower position shall be such as to afford a clear climbing space of at least thirty (30) inches.

(b) In case of collinear construction between Class **A** and Class **C** lines, Class **A** lines shall, where possible, occupy the upper position and shall conform to the requirements of Section III, except as modified by the following:

(i) The wires of the upper line may be spliced, but the ultimate strength of the splice shall be considered as ten (10) per cent. less than the average tested strength of the type of splice used.

(ii) The clearance between the top wire of the lower line and the bottom wire of the upper line shall not be less than six (6) feet under normal conditions.

(iii) The construction of the line in the lower position shall be such as to afford a clear climbing space of at least thirty (30) inches.

(iv) Lightning protection wires shall be grounded at least as frequently as in other portions of the line.

(c) Where it is not possible for the Class **A** or Class **B** lines to occupy the upper position, the conductors occupying the upper position shall be considered, insofar as mechanical strength of construction is concerned, as included in the class of power circuits of the highest voltage below them.

405. For cause shown, in special cases, the Commission may afford relief from the operation of these Regulations to any particular public utility when public convenience and safety will not be injuriously affected thereby, and the welfare of such public utility will be subserved by modifications of any of the foregoing Regulations and Specifications.

SECTION V.

SPECIFICATIONS FOR THE CONSTRUCTION OF OVERHEAD CROSSINGS OF COMMUNICATION LINES OVER RAILROADS.

SCOPE.

501. These specifications apply to crossings of Class **C** and Class **P** lines over tracks of railroads and their associated Class **C** or Class **P** wire lines in the same span. If Class **C** or Class **P** lines cross Class **A, B,** or **D** lines and railroad tracks in the same span, the Class **C** or Class **P** lines shall, where practicable, be below the Class **A,** B or **D** lines; however, if necessary for Class **C** or Class **P** lines to cross over railroad tracks, and Class **A, B** or **D** lines in the same span, the crossing, insofar as mechanical strength of construction is concerned, shall be in accordance with Section VI.

GENERAL.

502. **Location of Poles.** The poles supporting the crossing span and the next adjoining span, where practicable, shall be located in a straight line.

503. **Falling Trees.** The crossing span and the next adjoining spans, so far as practicable, shall be kept free from trees which might fall into the line.

504. **Fire Hazard.** The poles of the crossing span, so far as practicable, shall be located away from inflammable material or structures.

505. **Length of Span.** The length of the crossing span shall be as short as practicable, and in general shall not be greater than the normal span of the line. No crossing span should exceed 150 feet in length. The length of the next adjoining spans,

where practicable, shall be not greater than one and one-half (1½) times the length of the crossing span.

506. Grading. Whenever practicable, the difference in elevation of the wire supports, at the crossing poles and the poles next adjacent, shall not be greater than five (5) feet. It is desirable that this difference of elevation be less than five (5) feet.

CLEARANCES.

507. Clearance of Poles. Unless physical conditions or municipal requirements prevent, the side clearance between the poles of the crossing span and the nearest track rail shall not be less than twelve (12) feet, except that at sidings a clearance of not less than seven (7) feet may be allowed. At loading sidings sufficient space shall be left for a driveway.

508. The poles of the line making a crossing shall be so located that no interference with the existing lines, or with the free use of the poles, shall result.

509. Clearence Over Rails. The vertical clearance between the conductors of the crossing span and the top of the rail shall, under normal conditions (sixty (60) degrees Fahrenheit and no wind or ice loading), be not less than twenty-seven (27) feet.

510. Clearance Over Wires. The vertical clearance between conductors of the crossing span and conductors of the span crossed, where carried on separate poles, shall under normal conditions (sixty (60) degrees Fahrenheit and no wind or ice loading), be not less than four (4) feet.

511. Spacing of Conductors. The separation of conductors in the crossing span shall preferably be not less than twelve (12) inches, but in no case less than six (6) inches. Not more than ten (10) wires shall be supported by one set of double arms.

512. Vertical Spacing of Conductors. The vertical clearance between conductors supported on the same pole or structure shall preferably be twenty-four (24) inches, but in no case less than twelve (12) inches.

NOTE:—The requirements of Paragraphs 511 and 512 do not apply to conductors in cable or to twisted pair wires.

POLES.

513. Quality of Poles. Wooden poles supporting the crossing span shall be of chestnut, or other selected timber, and shall be sound and reasonably straight. They shall conform to the specifications for the proper class, as given in Appendix B. The several classes shall be used as follows:

For poles carrying not over 20 wires—Class C poles;
For poles carrying more than 20, and not more than 40, wires—Class B poles;
For poles carrying more than 40, and not more than 80, wires—Class A poles.

514. Pole Settings or Foundations. Poles shall be set in the ground to depths not less than those shown in the following tabulation:

Length of Poles (Feet)	Depth in Earth (Feet)
20	5.0
22	5.0
25	5.5
30	6.0
35	6.0
40	6.5
45	7.0
50	7.0
55	7.5
60	7.5

515. Where the poles are set in rock the depth of setting may be decreased depending upon its character, but this depth shall be not less than four (4) feet. By "length of pole" is meant the total length of the pole and not the height of the pole above the ground.

516. Where located in soft or swampy ground the setting of poles shall be suitably reinforced. This may be done by setting in barrels of broken stone or gravel, or in stone or timber footings, or by any other equally effective method.

517. Where located in the sides of banks of where subject to washouts, foundations or pole settings shall be given additional depth or protected by cribbing or riprap.

518. Back fillings for foundations or pole settings shall be carefullly tamped or otherwise thoroughly compacted while being placed.

519. Identification. For the purpose of identification poles shall be plainly marked with the name, initials or trade-mark of the owner of the poles.

GUYING.

520. Guying Required. The poles supporting the crossing span shall be head guyed away from the crossing span and side guyed in each direction. The number and size of guys shall be not less than given in the following table:

NUMBER OF WIRES IN CROSSING SPAN	NUMBER AND NOMINAL TENSILE STRENGTH OF GUYS	
	Head Guys	Side Guys (in each direction)
1 to 10 wires	1— 6,000 lb. strand	1— 6,000 lb. strand
11 " 20 "	1— 6,000 " "	1— 6,000 " "
21 " 30 "	1—10,000 " "	1— 6,000 " "
31 " 40 "	2— 6,000 " strands	1—10,000 " "
41 " 50 "	1—16,000 " strand	1—10,000 " "
51 " 60 "	2—10,000 " strands	1—16,000 " "
61 " 70 "	1—16,000 " strand 1—10,000 " "	1—16,000 " "
71 " 80 "	2—16,000 " strands	2—10,000 " strands

521. Location of Anchors. Guy anchors shall, where possible, be located so that the horizontal distance from the ground line of the pole to the guy or guy rod will be not less than the height above ground of the attachment of the guy to the poles, for head guys, and not less than one-third (1/3) that height, for side guys. Where the anchor for the head guy is located nearer to the pole than this distance, the amount of guying shall be increased to provide equivalent strength.

522. A different arrangement and number of guys than specified in Paragraph 520 may be used provided equivalent strength is obtained.

523. **Location of Guy Attachments to Poles.** On poles carrying one or two crossarms both head and side guys shall be attached under the upper crossarms. On poles carrying more than two crossarms the first head guy shall be attached below the second crossarm and successive head guys under the fourth and sixth crossarms. On poles carrying more than two crossarms side guys shall be attached below the second crossarm.

524. **Alternative Method of Guying.** Where on account of physical conditions it is impracticable to guy the crossing poles as specified in Paragraph 520, the requirements of this paragraph may be met by head guying and side guying the line as near as practicable to the crossing, but at a distance not exceeding 500 feet from the nearest crossing pole, provided; that a strand of strength equivalent to the head guy is run between the two guyed poles, being attached to the guyed poles at the point at which the head guys are attached, this strand being securely attached to every pole between the guyed poles.

525. Where the poles supporting the crossing span are not in line with the poles in the adjoining spans, additional guying shall be placed to take care of the increased strain.

526. **Pole Braces.** Braces may be used instead of guys to obtain the reinforcement above specified.

527. **Material for Guys.** Guys shall be of galvanized or copper covered stranded steel cable or rolled rods and must have a minimum nominal diameter of five-sixteenths (5/16) inch.

528. **Anchorage.** Guys to ground shall be connected to an anchor rod of such length that the eye of the rod shall be above the surface of the ground. Rods with a diameter of less than one (1) inch shall be galvanized.

529. **Guy Stubs.** Guy stubs or poles may be used in place of anchors provided the same amount of reinforcement is obtained by their use.

530. **Anchor Logs.** Anchor logs for use with different sizes of guy strand shall be of the dimensions and shall be set to the depths given in the following table:

Nominal Tensile Strength of Guy Strand	Minimum Depth of Excavation	Minimum Length and Width of Round Logs	Minimum Length and Width of Split Logs
6,000 lb.	4 ft.	3 ft. x 6 in.	3 ft. x 8 in.
10,000 "	5 "	4 " x 7 "	4 " x 10 "
16,000 "	5 "	6 " x 8 "	6 " x 12 "

531. The above sizes of logs and depths of setting apply to soil of average compactness. In loose sandy soil the depth of setting or the length of the logs shall be adequately increased.

CROSSARMS.

532. **Crossarms.** Wooden crossarms carrying the crossing span shall be of long-leaf yellow pine, fir or other suitable timber and shall have a minimum section of three (3) inches by four and one-quarter ($4\frac{1}{4}$) inches. Galvanized or painted iron, or steel crossarms, of equal strength may be used.

533. Crossarms shall be double on the crossing poles and shall be held together with properly fitted spacing blocks or bolts placed immediately adjoining the outside pins. Both crossarms shall be properly fitted in gains and held in place by not less than one five-eights ($\frac{5}{8}$) inch through bolt. Both arms shall be fitted with galvanized iron or steel braces not less than three-sixteenths (3/16) inch by one and three-sixteenths (1 3/16) inches by twenty-six (26) inches long which shall be attached to the crossarms by a lag screw not less than two and one-quarter ($2\frac{1}{4}$) inches by three-eighths ($\frac{3}{8}$) inch or a carriage bolt not less than four (4) inches by three-eighths ($\frac{3}{8}$) inch and to the pole by a fetter drive screw or lag screw not less than four (4) inches by one-half ($\frac{1}{2}$) inch or by not less than a one-half ($\frac{1}{2}$) inch through bolt.

PINS.

534. **Pins.** Insulator pins shall be of steel, wrought-iron, malleable iron, or locust wood. Locust pins shall be sound,

straight-grain locust, with a minimum diameter of shank of one and one-quarter (1¼) inches and a maximum length of eight (8) inches. Steel or iron pins shall have a minimum diameter of shank of one-half (½) inch and a maximum length of eight and three-quarter (8¾) inches.

INSULATORS.

535. **Insulators.** Each insulator shall be of such pattern, design and material that when mounted it will withstand without injury or without being pulled off the pin, the ultimate strength of the conductor attached to the insulator.

CONDUCTORS.

536. **Material of Conductors.** Conductors shall be of copper, copper covered steel, galvanized steel, or other corrosive resisting metal, provided however, that galvanized steel shall not be used in localities subject to excessive coal gases or other conditions which would cause excessive corrosion.

537. **Size of Conductors.** The minimum allowable sizes for conductors of the crossing span and adjoining spans are as follows:

Copper.

Spans 125 ft. or less	No. 10 A. W. Guage
" 126 ft to 150 ft.	No. 9 " "

Galvanized Steel.

Spans 125 ft. or less	No. 10 B. W. Gauge
" 126 ft to 150 ft.	No. 8 " "

If spans in excess of 150 feet are necessary, the size of conductor specified above shall be increased.

538. Conductors of material other than copper shall be of such size and so erected as to have a mechanical strength not less than that of the sizes of copper conductors given above.

539. The use of twisted pair wires without a messenger wire support shall be eliminated as far as practicable. In no case

shall this kind of wire be used in spans longer than one hundred (100) feet without a messenger wire support. Each wire of a twisted pair not supported by a messenger wire shall be tinned hard drawn copper not smaller than No. 14 A W. Gauge or tinned copper covered steel not smaller than No. 17 A. W. Gauge.

540. Sag of Conductors. Conductors of the crossing span shall be strung with sags not less than shown in the tables given in Appendix A.

541. Splices in Conductors. The conductors in the crossing span shall be free from splices or taps.

542. Conductor Attachments. Each conductor shall be attached to its insulators by tie wires. Copper and steel wires shall be tied to the insulators in the manner shown in Appendix H. Tie wires for copper or copper covered steel wires shall be of the same gauge as the line wire and of soft copper or of hard drawn copper which has been thoroughly annealed. Tie wires for steel line wire shall be of soft iron or steel and of the same gauge as the line wire up to and including No. 9 B. W. Gauge. Tie wires for No. 8 B. W. Gauge steel line wire or larger shall not be smaller than No. 9 B. W. Gauge.

CABLES.

543. Strand for Supporting Cables. Galvanized steel strand cable having a breaking strength of not less than 6,000 pounds shall be used to support cable of fifty (50) pairs of No. 19 A. W. Gauge copper conductors or their equivalent and smaller; or not less than 10,000 pounds breaking strength for cables in excess thereof up to 100 pairs of No. 19 A. W. Gauge copper conductors or their equivalent; and not less than 16,000 pounds breaking strength for cables containing more than 100 pairs No. 19 A. W. Gauge copper conductors or their equivalent. Not more than two messenger wires for supporting cable shall be attached to either pole of the crossing span.

544. Sag of Strand Supporting Cables. Cables shall be suspended with a minimum sag as follows:

Span in Feet	Minimum Sag in Inches
80 or less	16
90	20
100	22
110	26
120	30
130	34
140	40
150	44
175	62

545. **Attaching Cables to Messengers.** Cables shall be attached to messenger wire supports by means of galvanized metal rings or hangers, or marline, or marline hangers. The method of attachment shall be such as to develop the full strength of the messenger wire.

GALVANIZED MATERIAL.

546. **Galvanizing.** Galvanized material shall meet the requirements specified by the National Electric Light Association or other standards generally sanctioned by good modern practices.

Sherardizing of small parts is permitted.

All holes in galvanized material shall be made before galvanizing.

OTHER CONSTRUCTION REQUIREMENTS.

547. Auxiliary construction, such as guy attachments to poles, guy clamps, anchorages, etc., not definitely covered by these specifications, shall be of such design and strength as to develop the full strength of that member of which they are a part.

548. Construction requirements not covered by these specifications shall be according to the best modern practice.

549. For cause shown, in special cases, the Commission may afford relief from the operation of these Regulations to any particular public utility when public convenience and safety will not be injuriously affected thereby, and the welfare of such public utility will be subserved by modifications of any of the foregoing Regulations and Specifications.

SECTION VI.

SPECIFICATIONS FOR THE CONSTRUCTION OF OVERHEAD CROSSINGS OF POWER LINES OVER RAILROADS.

SCOPE.

601. These specifications apply to crossings of Class **A, B** and **D** lines over tracks of railroads, and over their associated paralleling wire lines located on the same right-of-way; also in respect to mechanical strength of construction to crossings of Class **C** and Class **P** lines over railroad tracks and over Class **A, B** or **D** wires in the same span.

GENERAL.

602. **Position at Crossings.** At crossings, conductors should generally be arranged in the order of the operating voltage, conductors of greatest voltage occupying the highest position, with the exception of trolley contact wires, which must necessarily occupy the lowest position, and trolley feeders which, for practical purposes, are generally run in approximately the same horizontal plane as the trolley contact wires to which they connect.

In crossing over trolley wires and feeders, or where it is impracticable to have the higher voltage wires above, the conductors occupying the upper position shall be considered, insofar as mechanical strength of construction is concerned, as included in the class of power circuits of the highest voltage below them.

603. **Location of Poles.** The poles or towers supporting the crossing span and the next adjoining spans, where practicable, shall be located in a straight line.

604. **Falling Trees.** The crossing span and the next adjoining spans, so far as practicable, shall be kept free from trees which might fall into line.

605. **Fire Hazard.** The poles or towers of the crossing span, so far as practicable, shall be located away from inflammable material or structures.

606. **Length of Span.** The length of the crossing span, where practicable, shall be not greater than the normal span of the line, and the length of the next adjoining span, where practicable, shall be not greater than one and one-half ($1\frac{1}{2}$) times the length of the normal span.

CLEARANCES.

607. **Side Clearance.** Unless physical conditions or municipal requirements prevent, the side clearance between supports of the crossing span and the nearest track rail shall not be less than twelve (12) feet, except that at sidings a clearance of not less than seven (7) feet may be allowed. At loading sidings sufficient space shall be left for a driveway.

608. **Overhead Clearance from Rail.** The vertical clearance between the conductors of the crossing span and the top of the rail shall be, under normal conditions (sixty (60) degrees Fahrenheit and no wind or ice load), not less than the following:

(a) Where the distance between the crossing supports does not exceed 150 feet, twenty-six (26) feet plus the minimum separation between conductors as tabulated in Paragraph 612.

(b) Where the distance between the crossing supports exceeds 150 feet, clearance as specified in (a), above, shall be increased two (2) inches for each ten (10) feet in length of crossing span in excess of 150 feet.

(c) Trolley contact wires and trolley feeders are excepted from the above. The minimum clearance for trolley contact wires shall be twenty-two (22) feet and for trolley feeders twenty-five (25) feet.

609. Overhead Clearance from Wire Lines. The vertical clearance between conductors of the crossing span and conductors of the associated paralleling wire lines of the railroad crossed, where carried on separate poles, shall be, under normal conditions (sixty (60) degrees Fahrenheit, and no wind or ice loading), not less than the sum of the values of (a) and (b) determined as below, but in no case, where voltage is more than 7,500, less than six (6) feet.

(a) One-tenth (1/10) of a foot for each kilo-volt, with a minimum value of four (4) feet.

(b) Two (2) inches for each ten (10) feet of the total distance obtained by adding together the distance from the point of crossing to the nearest pole supporting the crossing span, and the distance from the point of crossing to the nearest pole supporting the span crossed.

NOTE:—Where conductors of Class **D-2** are involved, the conductors of the crossing span shall be sufficiently raised above Class **D-2** wires, or otherwise protected to guard against damage from contact with trolley poles which may leave the trolley contact wires.

610. Clearance of Poles. The poles of the line making a crossing shall be so located that no interference with the existing lines, or with the free use of the poles of either line, shall result.

611. Clearance of Guys. The clearance, under normal conditions, between conductors of one line and guy wires of another line, where practicable, shall be not less than one-tenth (1/10) foot for each kilo-volt with a minimum of four (4) feet.

612. Spacing of Conductors. The minimum separation in any direction, at the points of support, for power conductors carrying a difference of potential and supported on pin type insulators, shall be one (1) inch for each twenty (20) feet of span, and one (1) inch additional for each foot of normal sag, but in no case shall the separation be less than that shown in the following table:

VOLTAGE BETWEEN CONDUCTORS Exceeding	 Not Exceeding	Separation
	7,000	12 in.
7,000	14,000	20 in.
14,000	27,000	30 in.
27,000	35,000	36 in.
35,000	47,000	45 in.
47,000	70,000	60 in.
70,000		60 in. plus 0.6 in. per k.v. in excess of 70.

Where supported by insulators of the disc or suspension type, the minimum separation of conductors shall be increased by twenty-five (25) per cent., unless dead ended or otherwise prevented from swinging.

NOTE:—The separations specified in this paragraph do **not apply** to pole wiring.

613. **Clearance between Conductors and Supports.** Clearance between any power conductor, or live hardware, and any portion of the supporting structure (insulator pins not included), shall not be less than three (3) inches, plus twenty-five hundredths (0.25) of an inch for each kilo-volt in excess of seven (7). For conductors supported by suspension or disc type insulators and not dead ended at the pole structure, or otherwise prevented from swinging, clearance as above shall be figured on the assumption that the maximum deflection of the supporting insulators is forty-five (45) degrees from the vertical.

614. **Gain Spacing.** In no case shall the gain spacing between crossarms (buck arms excepted), be less than twenty-four (24) inches.

CONDUCTORS.

615. **Material of Conductors.** Conductors shall be of copper, copper-covered steel, aluminum, galvanized steel, or other corrosion resisting material, provided, however, that galvanized steel shall not be used in localities subject to excessive coal gases, or other conditions which would cause unusual corrosion.

616. **Size of Conductors.** The minimum allowable sizes for conductors of the crossing and adjoining spans are as follows:

Copper or Copper-covered Steel	
Spans less than 150 feet.	No. 6 Am. Wire Gauge
Spans 150 feet and over	No. 4 " " "
Aluminum	No. 1 " " "
Galvanized Steel	5/16 in. diameter.

617. All aluminum and galvanized steel conductors shall be stranded.

NOTE:—The information available at present is not sufficient to show conclusively the relative reliability of stranded and solid copper conductors. Information is being collected on this subject and, until these data are available, no requirement as to the use of stranded or solid copper conductors is considered advisable.

618. **Sag of Conductors.** Conductors of the crossing and adjoining spans shall be strung with at least such sags as to withstand, with the designated factor of safety (Paragraph 661), the stresses due to the specified loading (Paragraph 658). See Appendix **C** for table of sags.

619. **Splices in Conductors.** The conductors in the crossing span shall be free from splices or taps. If a splice or tap is employed in any conductor in the next adjoining span, it shall be placed at a point nearer the crossing support than the distance from the crossing support of that conductor to the nearest wire crossed.

NOTE:—Where crossing is made under existing wires, the above requirement regarding splices may be waived with the consent of all parties in interest.

LIGHTNING PROTECTION WIRES.

620. **Lightning Protection Wires.** Lightning protection wires or cables, if used, shall conform to the requirements of specifications for conductors (Paragraphs 615, 616, 617, 618 and 619). When such wires are not connected to thoroughly grounded steel structures, they shall be permanently connected

to ground, at each crossing pole or tower, by a wire with a conductivity not less than No. 4 A. W. G. copper. The ground wire shall be connected directly to the lightning protection wire and to a well-made ground, and the course of this ground connection shall be as straight as possible.

INSULATORS.

621. **Material of Insulators.** Insulators on power lines shall be of porcelain, or other material which can be shown, to the satisfaction of the parties in interest, to be equally good in respect to mechanical and electrical requirements and durability.

622. **Design of Insulators.** Insulators shall be so designed that their dry flash-over is not more than seventy-five (75) per cent. of their puncture voltage, at a frequency of sixty (60) cycles.

623. **Factor of Safety of Insulators.** Insulators supporting the crossing and adjoining spans shall be capable of withstanding, without flash-over, at a frequency of sixty (60) cycles, the normal circuit voltage multiplied by the following factors:

VOLTAGE OF CIRCUIT		FACTOR	
Exceeding	Not Exceeding	Dry	Wet
	9,000	6.0	4.0
9,000	14,000	5.3	3.5
14,000	27,000	4.5	3.0
27,000	35,000	3.9	2.6
35,000	47,000	3.6	2.4
47,000	60,000	3.3	2.2
60,000		3.0	2.0

By the term "wet" is meant a condition equivalent to a precipitation of one-fifth (1/5) inch of rain per minute at an angle of forty-five (45) degrees to the axis of the insulator.

624. **Tests.** Each completed pin type insulator for line voltages over 15,000, and each completed suspension insulator disc, shall be subjected to a routine factory test at dry flash-over voltage, at a frequency of sixty (60) cycles for five (5) conse-

cutive minutes, or any other test which may be generally sanctioned by good modern practice.

625. Voltage Measurements. Test voltages shall be determined by methods conforming to the standards of the American Institute of Electrical Engineers.

626. Strain Insulators. Strain insulators, when used in guys, shall meet the following mechanical and electrical requirements:

(a) Strain insulators shall be capable of withstanding the maximum mechanical stress to which the guy of which they are a part may be subjected, with the factors of safety given in Paragraph 661.

(b) Strain insulators installed in guys shall be capable of withstanding, without puncture or flash-over, twice the maximum line voltage carried on either pole to which the guy is attached.

CONDUCTOR ATTACHMENTS.

627. Pins. Insulator pins shall be of steel, wrought-iron or malleable iron, and shall be galvanized. Cast-iron pin bases may be used. Pins of locust wood may be used, provided conditions are such that digestion or rapid deterioration of wood pins does not occur.

628. Strength of Pins, Insulators and Fastenings. Insulators, pins and conductor fastenings (including clamps, ties and dead-ends), carrying the crossing span, shall be designed

(a) To withstand, with the designated factors of safety (Paragraph 661), the stresses produced by the conductor under the specified loading (Paragraph 658).

(b) To withstand, with the designated factors of safety (Paragraph 661), the stress due to the pull in one direction of the conductor supported,—the pull being taken as the tension in the conductor due to the specified load (Paragraph 658).

A longitudinal movement of the conductor will be permitted, provided this movement will not reduce the designated clearances at the point of crossing (Paragraphs 608 and 609), by more than twenty-five (25) per cent. of the clearance required in Paragraph 609. In the calculation of stress, no allowance shall be made for deformation, deflection or displacement of any part of the structure.

Method of Attaching Conductors to Insulators. When the stress in the conductor, under the specified loading (Paragraph 658), does not exceed 2,000 pounds, the method of attaching conductors to double pin type insulators by tie wires, as shown in Appendix D, Figure 1, may be used to meet the requirements of this paragraph.

When the stress in the conductor, under the specified loading (Paragraph 658), exceeds 2,000 pounds, or when conditions are such that suspension or disc type insulators are desirable, a method of attaching conductors, satisfactory to all parties in interest, shall be used.

For suggested methods, see Appendix D.

629. **Special Protection at Insulator.** Where metal pins are used at either of the two crossing supports, or where wood pins are used and the crossarms are grounded (wood pins and non-grounded construction being generally used in other parts of the line), the insulators used on such metal or grounded supports shall have an electrical factor of safety fifty (50) per cent. greater than at other parts of the line, but in no case less than as specified in Paragraph 623.

As an alternative, the conductors, at their points of attachment to the insulators at the crossing span, may be protected by arcing shields as shown in Appendix D.

NOTE:—The purpose of the foregoing requirements, described in Paragraphs 628 and 629, is to guard against the failure of the construction due to any of the following accidental conditions:

I. Mechanical Failures.

(a) Failure due to the stresses produced by the conductors under the specified loading (Paragraph 658).

(**b**) Failure due to unbalanced stresses in conductors, resulting from conductor, insulator, pin, or conductor fastening failing at the adjoining pole or tower.

(**c**) Failure due to a broken or damaged insulator.

II. Electrical Failures.

(**a**) Burning, by arcs or leakage current due to the failure of an insulator, pin, or conductor fastening, of any wooden part of the supporting structure which, if burned, would render the conductor liable to fall.

(**b**) Burning or weakening of the conductor, at the insulator, due to arcs or leakage current.

Other methods of guarding against these accidental conditions may be used, if agreed upon by the parties in interest, as being equally effective as the methods herein described.

CROSSARMS.

630. **Crossarms.** The crossarms carrying the crossing span shall be of at least the following dimensions:

(a) Wood crossarm—3½ in. x 4½ in.

(b) Steel " —3 in. x 3 in. x 5/16 in.

631. Crossarms carrying the crossing span shall be attached to the poles with through bolts and shall be equipped with suitable galvanized iron braces. Double crossarms shall be fitted with spacing bolts, equipped with spacing nuts and washers, pipe spacers, or similar construction, or with spacing blocks or plates.

632. **Strength of Crossarms.** The crossarms carrying the crossing span, including their fastenings to the poles or towers, shall be designed:

(a) To withstand, with the designated factors of safety (Paragraph 661), the stresses produced by the conductors under the specified loading (Paragraph 658).

(b) To withstand, at all times without failure, the unbalanced stress due to the combined pull in one direction of all the conductors supported,—the pull of each conductor being taken as the tension in the conductor due to the specified load (Paragraph 658).

In the calculation of stress, no allowance shall be made for the deformation, deflection or displacement of any part of the structure.

For method of figuring strength of double crossarms, see Appendix E.

SUPPORTING STRUCTURES.

633. **Wooden Poles.** Wooden poles supporting the crossing span shall be of chestnut or other selected timber, reasonably straight, peeled, free from defects which decrease their strength or durability, and not less than twenty-two (22) inches in circumference at the top.

634. **Steel Towers.** Steel for structures supporting the crossing span shall conform to the "Specifications for Structural Steel for Buildings," as adopted by the American Society for Testing Materials.

635. Design and workmanship shall be in accordance with good modern practice.

636. The form of the frame shall be such that stresses may be computed with reasonable accuracy, or the strength of the structure shall be determined by actual test.

637. Construction shall be such that all parts are accessible for inspection, cleaning and painting, and shall not permit of pockets in which water or dirt might collect.

638. The unsupported length of a tower leg shall not exceed 140 times its least radius of gyration.

The unsupported length of a secondary compression member, having figured stress, shall not exceed 180 times its least radius of gyration.

The unsupported length of a compression member, placed to reduce the unsupported length of a leg or secondary member (therefore having no figured stress), shall not exceed 200 times its least radius of gyration.

639. The minimum thickness of metal in galvanized structures shall be one-quarter (¼) inch for main members and three-sixteenths (3/16) inch for all other members. The minimum thickness of metal in painted structures shall be one-quarter (¼) inch.

640. **Strength of Supporting Structures.** The poles or towers supporting the crossing span shall be designed:

(a) To withstand, with the designated factor of safety (Paragraph 661), the combined stresses produced by their own weight, the specified wind pressure on the poles or towers (Paragraph 659), and the specified conductor loading (Paragraph 658), on all conductors supported in both the crossing span and the next adjoining span.

(b) To withstand, at all times without failure, the unbalanced stress due to the combined pull in the direction of the crossing of all the conductors supported,—the pull of each conductor being taken as the tension in the conductor due to the specified load (Paragraph 658).

NOTE:—In designing steel towers, to withstand this unbalanced stress, the maximum allowable unit fibre stress shall be:

For tension members: 24,000 lbs. per square inch.

For compression members: $24{,}000 - \frac{60L}{R}$ lbs. per square inch

In the case of wooden or steel poles, when head guys are used to meet this requirement, this unbalanced stress may be assumed to be distributed equally over one or more poles adjoining the crossing, provided all the construction between the crossing span and any such poles is in conformity with these specifications.

In the calculation of stress, no allowance shall be made for the deformation, deflection or displacement of any part of the structure.

641. In the case of wooden pole construction, where the requirements of Paragraph 640 (a) cannot be met except by the use of side guys or special structures, and it is physically impracticable to employ side guys at the crossing poles, the requirements of Paragraph 640 (a) may be met by side-guying the line as near as practicable to the crossing but at a distance not exceeding 500 feet from the point of crossing, provided:

(a) The side-guyed poles shall be designed to withstand the stress due to wind and ice loading transversely to the line, on the assumption that the whole transverse strain of the line, between the poles so side-guyed, is carried by them.

(b) The line between such guyed poles and the crossing shall be substantially in a straight line with the crossing poles.

(c) The average length of span between the guyed poles and the crossing shall not be in excess of 150 feet.

When these conditions are met, and the crossing line between the guyed poles is otherwise constructed in accordance with these specifications, then, for the intervening poles, considered individually, without reinforcement from adjoining poles, the requirements of Paragraph 640 (a) may be modified to the extent of reducing the specified factor of safety, depending upon the number of wires carried, as per the following table:

Number of Wires	Factor of Safety
4	4.0
6	3.5
12	2.0
18	1.4
24 or more	1.0

642. **Pole setting.** Poles shall be set in the ground to depths not less than those shown in the following tabulation:

Total Length of Pole (Feet)	Depth in Earth (Feet)
25	5.5
30	6.0
35	6.0
40	6.5
45	7.0
50	7.0
55	7.5
60	7.5
65	8.0
70	8.0
75	8.5
80	8.5

When poles are set in rock, the depth of the setting may be decreased, depending upon its character, but this depth shall never be less than four (4) feet.

643. Where located in soft or swampy ground, the setting of poles shall be suitably reinforced. This may be done by setting in barrels of broken stone or gravel, or in stone or timber footings, or by any other equally effective method.

644. Where located in the sides of banks, or where subject to washouts, foundations or pole settings shall be given additional depth, or be protected by cribbing or riprap.

645. Backfillings for foundations or pole settings shall be carefully tamped, or otherwise thoroughly compacted, while being placed.

646. **Foundations for Steel Towers.** Foundations for towers supporting the crossing span shall be adequate to withstand, with the designated factor of safety (Paragraph 661), the maximum stress to which they will be subjected when wires and structures are loaded in accordance with Paragraphs 640, 658 and 659.

647. In designing foundations for towers, the weight of concrete shall be considered as 140 pounds per cubic foot. The weight of "earth" (calculated at thirty (30) degrees from the vertical), shall be considered, in good ground, as 100 pounds per cubic foot. In swampy ground, special measures shall be taken to prevent uplift or depression.

648. The top of a concrete foundation, or casing, shall extend at least six (6) inches above the surface of the ground, except when pavements or sidewalks make this impracticable, and shall have sufficient slope to prevent collection of water.

649. **Identification.** For the purpose of identification, poles or structures supporting the crossing span shall be clearly marked with the name, initials, or trade-mark of the owner of the structure.

GUYS.

650. Use of Guys. Guys may be used in meeting the specified strength requirements for supports (Paragraph 640). The number and arrangement of guys shall be determined by the conditions existing at the crossing. Braces may be used instead of guys. Where head guys are installed on poles supporting the crossing span, they shall be so installed as not to increase appreciably the stress in the conductors of the crossing span.

651. Where poles, not self-supporting, are guyed, they become rigid structures acting only as struts, and the horizontal component of the load will be considered as taken entirely by the guys. Where steel structures, not self-supporting, are guyed, they act as struts and also as beams. In figuring the strength of such structures and their guys, the structures, considered alone, may be figured as carrying such portion of the horizontal component of the load, together with the vertical component of the load acting on the structure as a strut, as will not stress any part of the structure beyond the designated factor of safety (Paragraph 661). The remaining portion of the horizontal component of the load shall be figured as carried by the guys with the designated factor of safety (Paragraph 661).

652. Material. Guys shall be galvanized or copper covered stranded steel cable, or rolled rods, and must have a minimum nominal diameter of five-sixteenths (5/16) inch.

653. Anchorage. Guys to ground shall be connected to a well-anchored rod of such length that the eye of the rod shall be above the surface of the ground. Rods with a diameter of less than one (1) inch shall be galvanized.

654. Guy anchors shall, when practicable, be placed at a horizontal distance from the poles they reinforce, measured at the ground line, of not less than one-third (1/3) of the height of the point of attachment of the guy to the pole.

655. Guy Stubs. Guy stubs, or poles used as guy stubs, with their foundations, anchorages and reinforcements, shall be adequate to withstand, with the designated factor of safety (Paragraph 661), the maximum stress to which they will be subjected when wires and structures are loaded in accordance with Paragraphs 640, 658 and 659.

656. Strain Insulators. A strain insulator, when used, shall conform to requirements of Paragraph 626, and in general shall be placed not less than six (6) feet below the lowest conductor, not less than eight (8) feet above the ground, and, where practicable, not less than six (6) feet, in a horizontal direction, from the pole. When it is impracticable to comply with the provisions of Paragraph 611, strain insulators shall be so placed as to protect pedestrians and men working on either line. Guys not equipped with strain insulators shall be permanently and effectually grounded.

PROTECTIVE COATINGS.

657. Protective Coatings on Steel. All structural steel shall be thoroughly cleaned at the shop, and shall be galvanized or painted, as follows:

(a) *Painting.* Painting shall consist of one (1) complete shop coat, one (1) field coat on all contact surfaces before assembling, and one (1) complete field coat after assembling. Before painting in the field, the surface of the metal shall again be thoroughly cleaned of all dirt, grease, etc., and worn or defaced spots shall be touched up. No painting shall be done in freezing or rainy weather.

(b) *Galvanizing.* Galvanized material shall meet the requirements specified by the National Electric Light Association, or other standard generally sanctioned by good modern practice.

Sherardizing of small parts is permitted.

All holes in galvanized material shall be made before galvanizing.

LOADS.

658. Loads. The conductors shall be considered as loaded uniformly throughout their length with a load equivalent to the resultant of the dead load, the weight of a layer of ice one-half (½) inch in thickness, and a wind pressure of eight (8) pounds per square foot of ice-covered diameter, at a temperature of zero (0) degrees Fahrenheit. The weight of the ice shall be assumed as fifty-seven (57) pounds per cubic foot (0.033 pounds per cubic inch).

659. The supporting structures shall be considered as subjected to a wind pressure of:

(a) Eight (8) pounds per square foot on the projected area of cylindrical surfaces, such as wood or tubular steel poles.
(b) Thirteen (13) pounds per square foot on the projected area of flat surfaces, such as cross-arms, etc.
(c) Thirteen (13) pounds per square foot on twice the projected area of one of two parallel faces of latticed or trussed structures.

The areas above enumerated shall be considered as increased by one-half (½) inch of ice on all the exposed surfaces.

660. Temperatures. Computation of stresses due to the temperature load shall be based upon an assumed temperature of minus twenty (—20) degrees Fahrenheit.

GENERAL REQUIREMENTS.

661. Mechanical Factors of Safety. In design and construction the ultimate unit strength divided by the allowable working unit stress shall be not less than the values shown in the following tabulation:

Wires, cables and conductor attachments	2
Pins	2
Pole line hardware	2
Line insulators (mechanical)	3
Guy insulators—non-interlocking	3
" " —interlocking	2
Guys	3
Wooden poles	4
Wooden crossarms	4
Structural steel poles, towers and crossarms	3
Reinforced concrete poles and crossarms	4
Foundations and anchorages	2

Allowable working unit stresses, as given in Appendix F, are derived by dividing generally approved ultimate unit strengths by the factors of safety shown above.

662. **Other Construction Requirements.** Construction requirements for all crossings, where not covered by these specifications, shall be according to the best modern practice.

ALTERNATIVE TYPES OF CONSTRUCTION.

663. The following describes methods of construction which offer alternatives to some of the foregoing requirements. Unless specifically excepted, all the foregoing requirements will apply to these types of construction.

664. **Short Span Method.** This method consists in making a short span at such a height that the radial distance, from the lowest insulators of the crossing span to the nearest wires of the span crossed, is greater than the length of the crossing span.

Conductors not meeting the requirements of Paragraphs 615 to 619, inclusive, may be used, provided a grounded guard arm is placed on each of the crossing poles or towers in such a manner as to prevent the upper wires in the next adjoining spans from whipping back into the wires crossed in case of failure of the upper wires. The requirements which may be omitted when this construction is used are Paragraphs 606, 615 to 619, inclusive, and 621 to 625, inclusive.

If conductors which meet the requirements of Paragraphs 615 to 619, inclusive, are used, and the next adjoining spans to the crossing are not less in length than twice the height above ground of the highest wire of the crossing spans, the grounded guard arms may be omitted.

To avoid the necessity for poles or towers of excessive height, as supports for the crossing span:

(a) The line crossed shall be built as low as possible.

(b) On Class **C** lines so crossed, the horizontal distance between conductors may be reduced to permit the crossing poles or towers to be placed nearer together.

See Appendix G.

665. Use of Cable. The power wires may be carried in aerial, armored, or metal sheath cable, in which case the requirements of the following paragraphs may be omitted:

609, 612 to 614, inclusive
621 to 625, inclusive
627, 628 and 629.

The vertical clearance from the cable to any conductor of the span crossed shall be not less than forty (40) inches.

The provisions of Paragraphs 615, 616, 617, 618 and 619 shall apply to the supporting messenger wire, but not to the cable or cable conductors.

The provisions of Paragraphs 630, 631 and 632 shall apply where cable is suspended from crossarms and not otherwise.

The messenger and armor or metal sheath of the cable shall be permanently and effectually grounded. The cable shall extend at least one span on each side of the crossing. The cable shall be capable of withstanding at least twice the normal line voltage between any two conductors, or between any conductor and the sheath or armor.

666. For cause shown, in special cases, the Commission may afford relief from the operation of these Regulations to any particular public utility when public convenience and safety will not be injuriously affected thereby, and the welfare of such public utility will be subserved by modifications of any of the foregoing Regulations and Specifications.

SECTION VII.

SPECIFICATIONS FOR THE CONSTRUCTION OF OVERHEAD LINES CROSSING UNDER RAILROAD BRIDGES.

701. Scope. These specifications apply to crossings under railroad bridges of all classes of overhead lines.

702. Use of Cable. Conductors may be installed beneath bridges in a metal conduit, or armored or metal sheath cable. The conduit or messenger (if any), and the armor or metal sheath of the cable shall be permanently and effectually grounded. The insulation of such conductors shall be capable of withstanding at least twice the normal line voltage between any two conductors or between any conductor and the sheath or armor. If such conductors are attached to the bridge structure, they shall be supported in accordance with Paragraph 706.

703. Clearance from Abutments. The clearance between any conductor and the face of the abutment shall be not less than three (3) feet for steel bridges, or other bridges with accessible wing walls, or one (1) foot for concrete slab, and brick, stone or concrete arch bridges with inacessible wing walls or without wing walls, but in no case shall the clearance between any conductor and the face of the abutment be less than that required in Paragraph 704.

704. Clearance from Bridge Structures. The clearance between any conductor, attached to the bridge in open construction, and any portion of the bridge structure, shall be not less than the following:

NOMINAL OPERATING VOLTAGE		CLEARANCE	
Exceeding	Not Exceeding	Minimum	Preferable
	2,500	6 in.	1 ft.
2,500	5,000	1 ft.	2 ft.
5,000	7,000	3 ft.	
7,000	14,000	5 ft.	
14,000	27,000	7.5 ft.	
27,000	35,000	9 ft.	
35,000		12 ft.	

705. Separation of Conductors. The separation between conductors attached to bridges in open construction shall be not less than the following:

Distance Between Supports	Minimum Distance Between Conductors
Up to 20 ft.	6 in.
20 ft. " 50 ft.	9 in.

706. Distance between Supports. Conductors attached to the under side of bridges shall have at least two points of support; the distance between supports shall not exceed fifty (50) feet.

707. Insulating Material. Insulators on Class **B,** Class **C** and Class **D-1** lines shall be of porcelain, glass or other reliable insulating material. Insulators on Class **A** and Class **D-2** lines shall be of porcelain or other material which can be shown to the satisfaction of the parties in interest, to be equally good in respect to mechanical and electrical requirements and durability.

708. Factor of Safety of Insulators. Insulators supporting the crossing and adjoining spans shall be capable of withstanding without flash-over, at a frequency of sixty (60) cycles, the normal circuit voltage multiplied by the following factors:

VOLTAGE OF CIRCUIT		FACTOR	
Exceeding	Not Exceeding	Dry	Wet
	9,000	6.0	4.0
9,000	14,000	5.3	3.5
14,000	27,000	4.5	3.0
27,000	35,000	3.9	2.6
35,000	47,000	3.6	2.4
47,000	60,000	3.3	2.2
60,000		3.0	2.0

By the term "wet" is meant a condition equivalent to a precipitation of one fifth (1/5) inch of rain per minute at an angle of forty-five (45) degrees to the axis of the insulator.

709. Tests. Each completed pin insulator for line voltages over 15,000, and each completed suspension insulator disc, shall be subjected to a routine factory test at dry flash-over voltage, at a frequency of sixty (60) cycles for five (5) consecutive minutes, or any other test which may be generally sanctioned by good modern practice.

710. Voltage Measurements. Test voltages shall be determined by methods conforming to the standards of the American Institute of Electrical Engineers.

711. Protection from Arcing at Insulator. When power lines are attached to steel bridges (wood pins and non-grounded construction being generally used in other parts of the line), the insulators used at the bridge attachments shall have an electrical factor of safety fifty (50) per cent. greater than at other parts of the line, but in no case less than as specified in Paragraph 708.

712. Conductor Attachment. Conductors attached to bridges in open construction shall be attached to pin type insulators by tie wires or clamps. Suggested methods of attachment are shown in Appendix D.

713. Pins. Insulator pins shall be of steel, wrought-iron or malleable iron, and shall be galvanized. Cast-iron pin bases may be used. Pins of locust wood may be used, provided conditions are such that digestion or rapid deterioration of wood pins does not occur.

714. Pin Supports. Wooden pin supports shall not be less than three (3) inches by four and one-fourth (4¼) inches in section. Suggested method of supporting under steel bridges is shown in Appendix I, Figure 1. Where open construction is used, pin supports shall be so arranged that insulators shall be used in the position for which they are designed.

715. Identification. The pin supports attached to the bridge shall be plainly marked with the name, initials or trade-mark of the owner of the structure, and in addition, for voltages in excess of 500, by a sign reading **"Danger—Do Not Touch."**

716. Trolley Contact Wires. Trolley contact wires attached to bridges shall be provided with a substantial, inverted trough of non-conducting material, or other means to keep the trolley pole from contact with the bridge structure. This protection shall be not less in length than the overall width of the bridge, measured along the line of the protection. Suggested method is shown in Appendix I, Figure 2.

717. Crossing Without Attachment. When clearances between all conductors in open construction in any direction from the bridge structure, as given in the following tabulation, are obtained without attachment to the bridge structure, the provisions of Paragraphs 704 to 716, inclusive, do not apply, and the line may be built according to Section II of these specifications.

NOMINAL OPERATING VOLTAGE		
Exceeding	Not Exceeding	Clearance
	7,000	3 ft.
7,000	14,000	5 ft.
14,000	27,000	7.5 ft.
27,000	35,000	9 ft.
35,000		12 ft.

718. For cause shown, in special cases, the Commission may afford relief from the operation of these Regulations to any particular public utility when public convenience and safety will not be injuriously affected thereby, and the welfare of such public utility will be subserved by modifications of any of the foregoing Regulations and Specifications.

SECTION VIII.

SPECIFICATIONS FOR THE CONSTRUCTION OF OVERHEAD LINES CROSSING RAILROADS BY MEANS OF UNDERGROUND CONSTRUCTION.

801. **Scope.** These specifications apply to the crossings of all classes of wire lines crossing railroad tracks underground.

802. **Conduit.** Wires or cables shall be carried in some suitable form of vitrified earthenware, treated fibre, creosoted wood duct or iron pipe conduit, of a size sufficient to permit the wires or cables to be readily drawn in, and shall terminate in manholes, pull boxes or terminals. Wherever practicable, such manholes, pull boxes or terminals shall not be placed on the railroad right of way.

803. **Depth.** The top of the conduit shall be located at a depth of not less than four (4) feet below the base of the rail, nor less than two (2) feet, six (6) inches below the surface of the ground at the lowest point of crossing of the railroad right of way. Wherever practicable, conduit shall be laid with a uniform slope of not less than three (3) inches per 100 feet, to drain away from the crossing.

804. **Terminals.** Where manholes, pull boxes or terminals project above the elevation of the top of the rail, unless physical conditions or municipal requirements prevent, they shall have horizontal clearance from the nearest track rail of not less than twelve (12) feet, except that at sidings a clearance of seven (7) feet may be allowed. At loading sidings, sufficient space shall be left for a drive-way.

805. **Protection.** Conduit, excepting iron pipe, located at a depth of less than six (6) feet below the top of the rail, shall

be protected on top by a slab of concrete not less than six (6) inches in thickness, or by creosoted wooden planks not less than two (2) inches in total thickness; this protection shall extend not less than three (3) inches on each side beyond the outer lines of the conduit.

NOTE:—In using creosoted planks to meet this requirement, more than one plank may be used.

806. For cause shown, in special cases, the Commission may afford relief from the operation of these Regulations to any particular public utility when public convenience and safety will not be injuriously affected thereby, and the welfare of such public utility will be subserved by modifications of any of the foregoing Regulations and Specifications.

SECTION IX.
APPENDICES.
APPENDIX A.

Section II, Paragraph 210
Section V, Paragraph 540.

Minimum Sags for Hard and Soft Drawn Copper Wire.

NOTE:—These tables are to be used in constructing only such crossings as come within the scope of Sections II and V. For sag tables to be used in connection with Sections III and VI, see Appendix C.

No. 10 A. W. G. HARD DRAWN BARE COPPER WIRE.

Temperature.

Length of Span In Feet	0° F.	20° F.	40° F.	60° F.	80° F.	100° F.
80	1½	2	2½	3	3½	5
90	2	2½	3	3½	4½	6
100	2½	3	3½	4½	5½	7
110	3	3½	4½	5½	6½	8½
120	5	6	7	9	11½	14½
130	8½	10½	13	16½	19½	23
140	15½	19	22½	25½	29	32
150	25½	29	32½	35½	38	41

No. 6 A. W. G. SOFT DRAWN COVERED COPPER WIRE.

Temperature.

Length of Span In Feet	0° F.	20° F.	40° F.	60° F.	80° F.	100° F.
60	3	4	5	6	8	9
70	5	6	7	9	11	12
80	6	7	10	12	14	15
90	8½	10	13	15	17	19
100	12	14	16	19	21	23
110	16	18	21	23	25	27
120	19½	22	25	27	30	32
130	25½	27	30	32	35	37
140	30½	33½	36	38½	41	43
150	39½	42	44½	46½	49	51

APPENDIX B.

SPECIFICATIONS FOR WOOD POLES

As Contained in

"HANDBOOK ON OVERHEAD LINE CONSTRUCTION"

of the

NATIONAL ELECTRIC LIGHT ASSOCIATION.

SPECIFICATIONS FOR CHESTNUT POLES.

To determine the character of poles to be used, pole lines may be divided into the three following classes:

Class "A": For heavy transmission lines or heavy distribution lines.

Class "B": For light transmission lines or ordinary distribution lines.

Class "C": For very light distribution lines or light secondary lines.

The purchasing company is to have the right to make such inspections of the poles as it may desire. The inspector of the purchasing company shall have the power to reject any pole which is defective in any respect. Inspection, however, shall not relieve the manufacturer from furnishing perfect poles.

Any imperfect poles which may be discovered before their final acceptance shall be replaced immediately upon the requirement of the purchasing company, notwithstanding that the defects may have been overlooked by the inspector. If the requirements of these specifications are not fulfilled when the poles are offered for final acceptance, not only shall the purchasing company have the right to reject the poles, but the expense of inspection of such defective poles shall be borne by the manufacturer.

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*National Electric Light Association Specification.

APPENDIX B—Page 2.

All poles shall be subject to inspection by the purchasing company, either in the woods where the trees are felled, or at any point of shipment or destination. Any pole failing to meet all the requirements of these specifications may be rejected.

All poles shall be of the best quality live white chestnut, squared at both ends, reasonably straight, well proportioned from butt to top, peeled and with knots trimmed close.

The dimensions of poles shall be according to the following table:

DIMENSIONS OF POLES IN INCHES.

LENGTH OF POLES (FEET)	CLASS "A"		CLASS "B"		CLASS "C"	
	Top	6 ft. from Butt	Top	6 ft. from Butt	Top	6 ft. from Butt
25	24	37	22	33	20	30
30	24	40	22	36	20	33
35	24	43	22	40	20	36
40	24	45	22	43	20	40
45	24	48	22	47	20	43
50	24	51	22	50	20	46
55	22	54	22	53	20	49
60	22	57	22	56		
65	22	60	22	59		
70	22	63	22	62		
75	22	66	22	65		
80	22	70	22	69		
85	22	73	22	72		
90	22	76	22	75		

the "Top" measurements being the circumference at the top of the pole, and the "Butt" measurement being the circumference six (6) feet from the butt.

SPECIFICATIONS FOR EASTERN WHITE CEDAR POLES.*

The material desired under these specifications consists of poles of the best quality of either seasoned or live green cedar of the dimensions hereinafter specified. Seasoned poles shall have preference over green poles provided they have not been held for seasoning long enough to have developed any of the

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*National Electric Light Association Specification.

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timber defects hereinafter referred to. All poles shall be reasonably straight, well proportioned from butt to top, shall have both ends squared, the bark peeled and all knots and limbs closely trimmed.

Dimensions.

The dimensions of the poles shall be in accordance with the following table, the "top" measurement being the circumference at the top of the pole, and the "butt" measurement the circumference six (6) feet from the butt.

MINIMUM DIMENSIONS OF POLES IN INCHES (CIRCUMFERENCE).

LENGTH OF POLES (FEET)	CLASS "A"		CLASS "B"		CLASS "C"	
	Top	6 ft. from Butt	Top	6 ft. from Butt	Top	6 ft. from Butt
25	24	36	22	32	18¾	30
30	24	40	22	36	18¾	33
35	24	43	22	38	18¾	36
40	24	47	22	43	18¾	40
45	24	50	22	47	18¾	43
50	24	53	22	50	18¾	46
55	24	56	22	53	18¾	49
60	24	59	22	56	18¾	52

When the dimension at the butt is not given the poles shall be reasonably well proportioned throughout their entire length.

The dimension requirement at the six (6) foot mark shall be rigidly followed in all cases. Class "A," "B" and "C" poles may have top circumference not more than one-half (½) inch less than those shown in the preceding table. No pole shall be over six (6) inches longer or three (3) inches shorter than the length for which it is accepted; if any pole be more than six (6) inches longer than is required it shall be cut back.

Quality of Timber.

Dead Poles. The wood of a dead pole is grayish in color. The presence of a black line on the edge of the sapwood (as seen on the butt) also shows that a pole is dead. No dead poles, and no poles having dead streaks covering more than one-quarter ($\frac{1}{4}$) of their surface shall be accepted under these specifications. Poles having dead streaks covering less than one-quarter ($\frac{1}{4}$) of their surface shall have a circumference greater than otherwise required. The increase in the circumference shall be sufficient to afford a cross-sectional area of sound wood equivalent to that of sound poles of the same class.

Fire Killed or River Poles. No dark red or copper colored poles, which when scraped do not show good live timber shall be accepted under these specifications.

Twisted, Checked or Cracked Poles. No poles having more than one complete twist for every twenty (20) feet in length, no cracked poles containing large season checks shall be accepted under these specifications.

"Cat Faces." No poles having "Cat Faces," unless they are small, and perfectly sound and the poles have an increased diameter at the "cat face," and no poles having "cat faces" near the six (6) foot mark, or within ten (10) feet of their tops, shall be accepted under these specifications.

Shaved Poles. No shaved poles shall be accepted under these specifications.

Miscellaneous Defects. No poles containing sap rot, evidence of internal rot as disclosed by a careful examination of all black knots, hollow knots, woodpecker holes, or plugged holes; and no poles showing evidences of having been eaten by ants, worms or grubs shall be accepted under these specifications, except that poles containing worm or grub marks below the six (6) foot mark will be accepted.

Crooked Poles. No poles having a short crook or bend a crook or bend in two planes or a reverse curve shall be accepted under these specifications. The amount of sweep, measured between the six (6) foot mark and the top of the pole, that may

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be present in poles acceptable under these specifications, is shown in the following table:

35 foot poles shall not have a sweep over 10½ inches.
40 foot poles shall not have a sweep over 12 inches.
45 foot poles shall not have a sweep over 9 inches.
50 foot poles shall not have a sweep over 10 inches.
55 foot poles shall not have a sweep over 11 inches.
60 foot poles shall not have a sweep over 12 inches.

Defective Tops. Poles having tops of the required dimensions must have sound tops. Poles having top one (1) inch or more above the requirements in circumference may have one (1) pipe rot not more than one-half (½) inch in diameter. Poles with double tops or double hearts shall be free from rot where the two parts or hearts join.

Defective Butts. No poles containing ring rot (rot in the form of a complete or partial ring) shall be accepted under these specifications.

Poles having hollow hearts may be accepted under the conditions shown in the following table:

	ADD TO BUTT REQUIREMENTS		
AVERAGE DIAMETER OF ROT	of 24 an 30 Foot Poles	of 35, 40. 45 Foot Poles	of 50, 55, 60. 65 Foot Poles
2 inches	Nothing	Nothing	Nothing
3 inches	1 inch	Nothing	Nothing
4 inches	2 inches	Nothing	Nothing
5 inches	3 inches	1 inch	Nothing
6 inches	4 inches	2 inches	1 inch
7 inches	Reject	4 inches	2 inches
8 inches	Reject	6 inches	3 inches
9 inches	Reject	Reject	4 inches
10 inches	Reject	Reject	5 inches
11 inches	Reject	Reject	7 inches
12 inches	Reject	Reject	9 inches
13 inches	Reject	Reject	Reject

Scattered rot, unless it is near the outside of the pole, may be estimated as being the same as heart rot of equal area.

"Wind Shakes." Poles with cup shakes (checks in the form of rings) which also have heart or star checks may be considered as equal to poles having hollow hearts of the average diameter of the cup shakes.

Inspection. All poles shall be subject to inspection by the purchaser's representative, either in the woods where the trees are felled, or at any point of shipment, or destination. Each pole thus inspected shall be marked according to its length and class with a marking hammer, by the purchaser's representative. All poles failing to meet these specifications shall be rejected.

SPECIFICATIONS FOR WESTERN WHITE CEDAR, RED CEDAR, WESTERN CEDAR, IDAHO CEDAR.*

General.

The material desired under these specifications consists of poles and guy stubs of the best quality of either seasoned or live green cedar of the dimensions hereinafter specified. The poles covered by these specifications are of Western White Cedar, otherwise known as red cedar, western cedar, or Idaho cedar. Seasoned poles shall have preference over green poles provided they have not been held for seasoning long enough to have developed any of the timber defects hereinafter referred to. All poles shall be reasonably straight, well proportioned from butt to top, shall have both ends squared, sound tops, the bark peeled, and all knots and limbs closely trimmed.

Dimensions.

The dimensions of the poles shall be in accordance with the following table, the "top" measurement being the circumference at the top of the pole and the "butt" measurement, the circumference six (6) feet from the butt. The dimensions given are the minimum allowable circumferences at the point specified for measurement and are not intended to preclude the acceptance of poles of larger dimensions.

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*American Telephone & Telegraph Company Specification.

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When the dimension at the butt is not given, the poles shall be reasonably well proportioned throughout their entire length. No pole shall be over six (6) inches longer or three (3) inches shorter than the length for which it is accepted. If any pole is more than six (6) inches longer than is required it shall be cut back.

MINIMUM DIMENSIONS OF POLES IN INCHES.

LENGTH OF POLES (FEET)	CLASS "A" (Minimum Top Circumference 28) Circumference 6 Feet from Butt	CLASS "B" (Minimum Top Circumference 25) Circumference 6 Feet from Butt	CLASS "C" (Minimum Top Circumference 22) Circumference 6 Feet from Butt
20	30	28	26
22	32	30	27
25	34	31	28
30	37	34	30
35	40	36	32
40	43	38	34
45	45	40	36
50	47	42	38
55	49	44	40
60	52	46	41
65	54	48	43

QUALITY OF TIMBER.

Dead Poles. No dead poles and no poles having dead streaks covering more than one-quarter of their surface shall be accepted under these specifications. Poles having dead streaks covering less than one-quarter of their surface shall have a circumference greater than otherwise required. The increase in the circumference shall be sufficient to afford a cross sectional area of sound wood equivalent to that of sound poles of the same class.

Twisted, Checked or Cracked Poles. No poles having more than one (1) complete twist for every twenty (20) feet in length, no cracked poles, and no poles containing large season checks, shall be accepted under these specifications.

Crooked Poles. No poles having a short crook or bend, a crook or bend in two planes, or a reverse crook or bend, shall be accepted under these specifications. The amount of sweep measured between the six (6) foot mark and the top of the pole, shall not exceed one (1) inch to every six (6) feet in length.

"Cat Faces." No poles having "cat faces," unless they are small and perfectly sound, and the poles have an increased diameter at the "cat face" and no poles having "cat faces" near the six (6) foot mark, or within ten (10) feet of their tops shall be accepted under these specifications.

Shaved Poles. No shaved poles shall be accepted under these specifications.

Wind Shakes. No poles shall have cup shakes (checks in the form of rings) containing heart or star shakes which enclose more than ten (10) per cent. of the area of the butt.

Butt Rot. No poles shall have butt rot covering in excess of ten (10) per cent. of the total area of the butt. The butt rot, if present, must be located close to the center in order that the pole may be accepted.

Knots. Large knots, if sound and trimmed close, shall not be considered a defect. No poles shall contain hollow or rotten knots.

Miscellaneous Defects. No poles containing sap rot, woodpecker holes or plugged holes, and no poles showing evidences of having been eaten by worms, ants, or grubs shall be accepted under these specifications.

SPECIFICATIONS FOR SAWED RED WOOD POLES.*

General. The material desired under these specifications consists of poles of redwood (Sequois Sempervirens) sawed to shape as hereinafter set forth.

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*American Telephone & Telegraph Company Specification.

APPENDIX B—Page 9.

Quality of Timber and Workmanship. All poles shall be of sound Number One Common Redwood; they should be reasonably straight and well sawn.

Dimensions. The dimensions of the poles shall be in accordance with the following table:

LENGTH IN FEET	"A"		"B"	
	Top	Butt	Top	Butt
24	6″ x 6″	6″ x 6″	4″ x 6″	4″ x 6″
25	7″ x 7″	10″ x 10″	6″ x 6″	9″ x 9″
30	7″ x 7″	11″ x 11″	6″ x 6″	10″ x 10″
35	7″ x 7″	12″ x 12″	6″ x 6″	11″ x 11″
40	7″ x 7″	13″ x 13″	6″ x 6″	12″ x 12″
45	7″ x 7″	14″ x 14″	6″ x 6″	13″ x 13″
50	7″ x 7″	15½″ x 15½″	6″ x 6″	14″ x 14″

The sectional dimensions of the sawn poles shall not be more than one-quarter (¼) of an inch under, or three-quarters (¾) of an inch over, the dimensions specified in the above table. No pole shall be more than three (3) inches longer or shorter than the lengths required in the above table.

Sapwood. No pole shall have sapwood covering more than four (4) per cent. of the area of all the surfaces. No pole shall have sapwood for a distance of more than eight (8) feet from the top. No sapwood shall be deeper than one (1) inch at any point.

Plugged Holes. No poles shall have plugged holes.

Cracked Poles. No poles shall contain cracks transverse to the length of the pole.

Checked Poles. No pole shall contain large season checks.

Wind Shakes. No pole shall contain wind shakes including in excess of ten (10) per cent. of the area of the butt.

APPENDIX B—Page 10.

Knots. No poles shall contain loose, hollow, or rotten knots, black or red knots shall be carefully examined for internal rot.

In four (4) inch by six (6) inch poles sound knots with a diameter smaller than one (1) inch may be present in any number. No four (4) inch by six (6) inch pole shall be accepted which contains more than one sound knot in each five (5) superficial feet having a diameter of one (1) inch or more, or which contains any knots with a diameter greater than one and one-half (1½) inch.

In all other sizes of poles covered by these specifications sound knots with a diameter smaller than one and one-half (1½) inches may be present in any number. No pole shall be accepted which contains more than one sound knot in each five (5) superficial feet having a diameter of one and one-half (1½) inches or more, or which contains any knots of a diameter greater than two and one-half (2½) inches.

NOTE:—Where diameters are specified in connection with knots, the knot shall be rated on the basis of its average diameter.

SPECIFICATIONS FOR YELLOW PINE POLES.*

Quality of Timber. All poles shall be cut from the best quality of live, straight grained, unbled, long leaf yellow pine. The butt end shall be squared and the top end pointed to an angle of forty-five (45) degrees. The poles shall be sawed octagonal in shape and shall be dressed, with the heart running parallel to the line of the pole. The timber shall be free of decayed or loose knots or clusters of small knots.

Classification and Dimensions. Poles shall be classified according to their butt dimensions into two classes, to be known as Class "A" poles and Class "B" poles, with dimensions for the respective classes as specified in the following table. Where "top" measurement is specified it shall be the diameter at the top of the pole and where "butt" measurement is specified it shall be at the diameter of the butt end of the pole.

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*National Electric Light Association Specification.

APPENDIX B—Page 11.

Inspection and Rejection. All poles shall be subject to inspection by the purchaser's representative, either in the woods where the trees are felled, or at any point of shipment, or destination. Each pole thus inspected shall be marked according to its length and class with a marking hammer, by the purchaser's representative. All poles failing to meet these specifications shall be rejected.

DIMENSIONS OF POLES IN INCHES (DIAMETER).

LENGTH OF POLES (FEET)	CLASS "A"		CLASS "B"	
	Top	Butt End	Top	Butt End
30	8	11	7	10
35	8	12	7	11
40	8	13	7	12
45	8	14	7	12
50	8	15	7	13
55	8	16	7	14
60	8	17		
65	8	18		

SPECIFICATIONS FOR CREOSOTED YELLOW PINE POLES.*

These specifications are for Class "A," "B" and "C" poles of Southern Yellow Pine treated with Dead Oil of Coal Tar.

Quality of Poles. All poles shall be sound southern yellow pine (longleaf, shortleaf or loblolly yellow pine) squared at the butt, seasoned, straight, well proportioned from butt to top, peeled and afterwards trimmed close. All poles shall be free from large or decayed knots. All poles shall be cut from live timber.

It is desired that all poles be well air seasoned before treatment and such poles shall be treated in accordance with the requirements for treating seasoned timber contained in the "Specifications for Creosoting Timber" referred to in Section 9. The poles shall not be held for seasoning, however, up to the point where local experience shows that sapwood decay would begin.

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*American Telephone & Telegraph Company Specification.

Unseasoned poles shall be treated in accordance with the requirements for treating unseasoned timber contained in the above mentioned specifications.

All poles shall be sufficiently free from adhering "inner bark" before treatment to permit the penetration of the oil. If the "inner bark" is not satisfactorily removed when the pole is peeled, the pole shall either be shaved, or be allowed to season until the "inner bark" cracks and tends to peel off of the surface of the pole.

Dimensions. The dimensions of the poles shall not be less than those given in the following table:

DIMENSIONS OF POLES IN INCHES (CIRCUMFERENCE).

LENGTH OF POLES (FEET)	CLASS "A" 6 ft. from Butt	CLASS "B" 6 ft. from Butt	CLASS "C" 6 ft. from Butt
25	33	30	28½
30	35	32	30½
35	38	34	32
40	40	36	34
45	42½	38	36
50	44½	40	38
55	47	42½	40
60	49	44½	42
65	51	47	44
70	53	49	46
75	55	51	
80	57		

No Class "A" poles having a top circumference of less than twenty-two (22) inches will be accepted.

No Class "B" poles having a top circumference of less than twenty (20) inches will be accepted.

No Class "C" poles having a top circumference of less than eighteen (18) inches will be accepted.

Framing of Poles. Before the poles are subjected to the creosoting process they shall be framed, as ordered.

APPENDIX B—Page 13.

The tops of all poles shall be roofed at an angle of ninety (90) degrees.

All Class "A" poles shall have eight (8) gains, all Class "B" poles shall have four (4) gains and Class "C" poles shall have two (2) gains.

The gains shall be located on the side of the pole with the greatest curvature, and on the convex side of the curve. The faces of all gains shall be parallel. Each gain shall be four and one-half (4½) inches wide and one-half (½) inch deep, spaced twenty-four (24) inches on centers. The center of the top gain shall be twelve (12) inches from the apex of the gable. A twenty-one-thirty-second (21/32) inch hole shall be bored through the pole at the center of each gain perpendicular to the plane of the gain.

Inspection. The quantity of dead oil of coal tar forced into the poles shall be determined by tank measurements, and by observing the depth of penetration of the oil into the pole. In the case of poles having a growth of sapwood not less than one and one-half (1½) inches in thickness, the depth of penetration shall be not less than one and one-half (1½) inches. In the case of poles having a growth of sapwood less than one and one-half (1½) inches in thickness, the dead oil of coal tar shall penetrate through the sapwood and into the heartwood.

Depth of penetration shall be determined by boring the pole with a one (1) inch auger. The right is reserved to bore for this purpose, two (2) holes at random about the circumference, one (1) hole five (5) feet from the butt and one (1) hole ten (10) feet from the top. After inspection each bore hole shall be first filled with hot dead oil of coal tar, and then with a close fitting creosoted wooden plug.

The rejection of any pole on the score of insufficient penetration shall not preclude its being retreated and again offered for inspection.

APPENDIX C.

CONDUCTOR SAGS.

The sag curves, Pages 92 to 110, inclusive, are divided into two sections:

First: Those showing the minimum sag under normal conditions (sixty (60) degrees Fahrenheit, no wind or ice loading) to which conductors may be strung so that when loaded with the specified loads (zero (0) degrees Fahrenheit, eight (8) pounds wind and one-half (½) inch of ice) the total tension will not exceed one-half (½) the ultimate strength of the conductors. (Section III, Paragraph 316, Section VI, Paragraph 618.)

Second: Those showing the minimum sag under normal conditions (sixty (60) degrees Fahrenheit, no wind or ice) to which conductors may be strung so that when the specified loads (zero (0) degrees Fahrenheit, eight (8) pounds wind and one-half (½) inch of ice) are imposed upon them the total tension will not exceed one-half (½) the ultimate strength of the conductors, with a maximum limit of 2,000 pounds. (Section III, Paragraph 326, Section VI, Paragraph 628.)

Sags For Unequal Spans, Level Supports and Normal Conditions.

When the crossing and adjoining spans are of different lengths it is not possible to so string the conductors so as to make both the normal tension and the loaded tension balance in the several spans. This condition should be met by selecting a sag for the **longest** span not less than that shown in the accompanying curves, Pages 96 to 114, inclusive. (Either group, as the case may be.)

The sags for the other spans should then be made proportional to the square of the **longest** span and the span considered. The total normal tension in each of the spans will then balance and the total tension under loaded conditions will be slightly less in the short spans than in the longest span.

APPENDIX C—Page 2.

Example:

Assume—A crossing span length of 300 ft.

Adjoining spans of 400 ft. and 200 ft., respectively.

Conductors No. 0 A. W. G., copper, hard drawn, solid, bare.

Sag from curve, Page 96, for a 400 ft. span is 8.9 ft.

Making the sags in the other spans proportional to the square of the spans; the sag in the 300 ft. span will be,

$$\frac{(300)^2 \times 8.9}{(400)^2} = 5.0 \text{ ft.}$$

The sag in the 200 ft. span will be,

$$\frac{(200)^2 \times 8.9}{(400)^2} = 2.22 \text{ ft.}$$

Sags for Supports at Different Elevations.

The sag curves have been based on the supports being at the same elevation. This condition is not always possible. The curve on Page 115 covers the correction of the sag curves to care for this condition.

The use of this correction may best be illustrated by taking a concrete case:

Example:

Assume—A span of 400 ft.

A difference in level of supports of 6 ft.

Conductors No. 0 A. W. G., copper, hard drawn, solid, bare.

The curve, Page 96, requires a sag of 8.9 ft.

The ratio of difference in level of supports divided by the sag is 6.0 divided by 8.9 equals 0.674, which is the ratio marked h/s on curve, Page 111. The multiplier C for this ratio is 0.692. Therefore the sag below the lowest point of support is,

$$0.692 \times 8.9 \text{ equals } 6.16 \text{ ft.}$$

APPENDIX C—Page 3.

If the sag is to be measured from the higher support, the sag below the lower support may be obtained as above and the difference in elevation of the supports added thereto, or the sag below the higher support is,

$$6.16 + 6.0 \text{ equals } 12.16 \text{ ft.}$$

Sag Correction for Temperature.

The curves, Pages 115 to 119, inclusive, cover the correction of sags for stringing temperatures other than that for which the sag curves were calculated. These figures cover the commercial range of stringing conditions for temperatures at time of stringing, varying between twenty (20) degrees Fahrenheit and 100 degrees Fahrenheit, and for spans of from 100 feet to 1000 feet, inclusive, in 100 foot steps, with the exception that a 150 foot span has also been included. They represent **average** values for each degree Fahrenheit difference between actual stringing temperatures and the temperature for which the curves were calculated; that is sixty (60) degrees Fahrenheit. The correction for twenty (20) degrees Fahrenheit above sixty (60) degrees Fahrenheit is different from the correction for twenty (20) degrees Fahrenheit below sixty (60) degrees Fahrenheit. The results have therefore been plotted for temperatures above and for temperatures below sixty (60) degrees Fahrenheit. The correction for temperatures greater than sixty (60) degrees Fahrenheit are to be **added** to the normal sags and **subtracted** for temperatures less than sixty (60) degree Fahrenheit.

The use of these corrections may be illustrated by assuming a specific case:

Example:

Assume—A span of 400 ft.
Conductors No. 0 A. W. G., copper, hard drawn, solid, bare.
Stringing temperature 75° F.
Minimum normal sag (Page 96) is 8.9 ft.
Difference between stringing temperature and normal temperature is 15° F.

The ratio for sag divided by span is 0.0223.

APPENDIX C—Page 4.

The correction per degree Fahrenheit for this ratio for temperatures greater than 60° for a span of 400 ft. (Page 113) is 0.0258.

Total correction for 15° F. difference is

15 × 0.0258 squals 0.387, or say 0.39.

Then the corrected sag is 8.9 plus 0.39 equals 9.29 ft.

If some other span than those covered by specific curves are used the correction may be obtained by interpolation between curves.

Determination of Amount of Sag for Various Points in a Span.

The sag curves, on Pages 96 to 114, inclusive, show for wires of different sizes and materials the value of the centre sag at which these wires should be strung under normal conditions to have the assumed factors of safety under the designated loaded conditions. At times it is desirable to know, not only the amount of the sag at the centre of the span, but also the amount of the sag at some other point in the span. This is necessary, for example, in obtaining the clearance over other wires where the point of crossing between the crossing span and the wires crossed, occurs, not at the centre of the crossing span, but at some other point.

On Page 120, there is given a curve by means of which, given the amount of the centre sag, there can be determined the amount of the sag at any other point in the span. This curve gives the value of the sag at all points on the catenary curve, expressed in per cent. of the centre sag. The use of the curve shown on this figure is as follows:

Example:

Assume—A span of 400 ft.

A centre sag, determined from the sag tables, of 8.9 ft.

The crossing span crosses over a Class **"C"** Line, on which the top wire at the point of this crossing has an elevation of 25 ft.

APPENDIX C—Page 5.

This point of crossing to be 120 ft. from the nearest support of the crossing conductor, and that a minimum vertical clearance of 6 ft. 6 in. is required at the point of crossing.

Required—At what height must the crossing conductor be supported in order that this required vertical clearance shall be obtained?

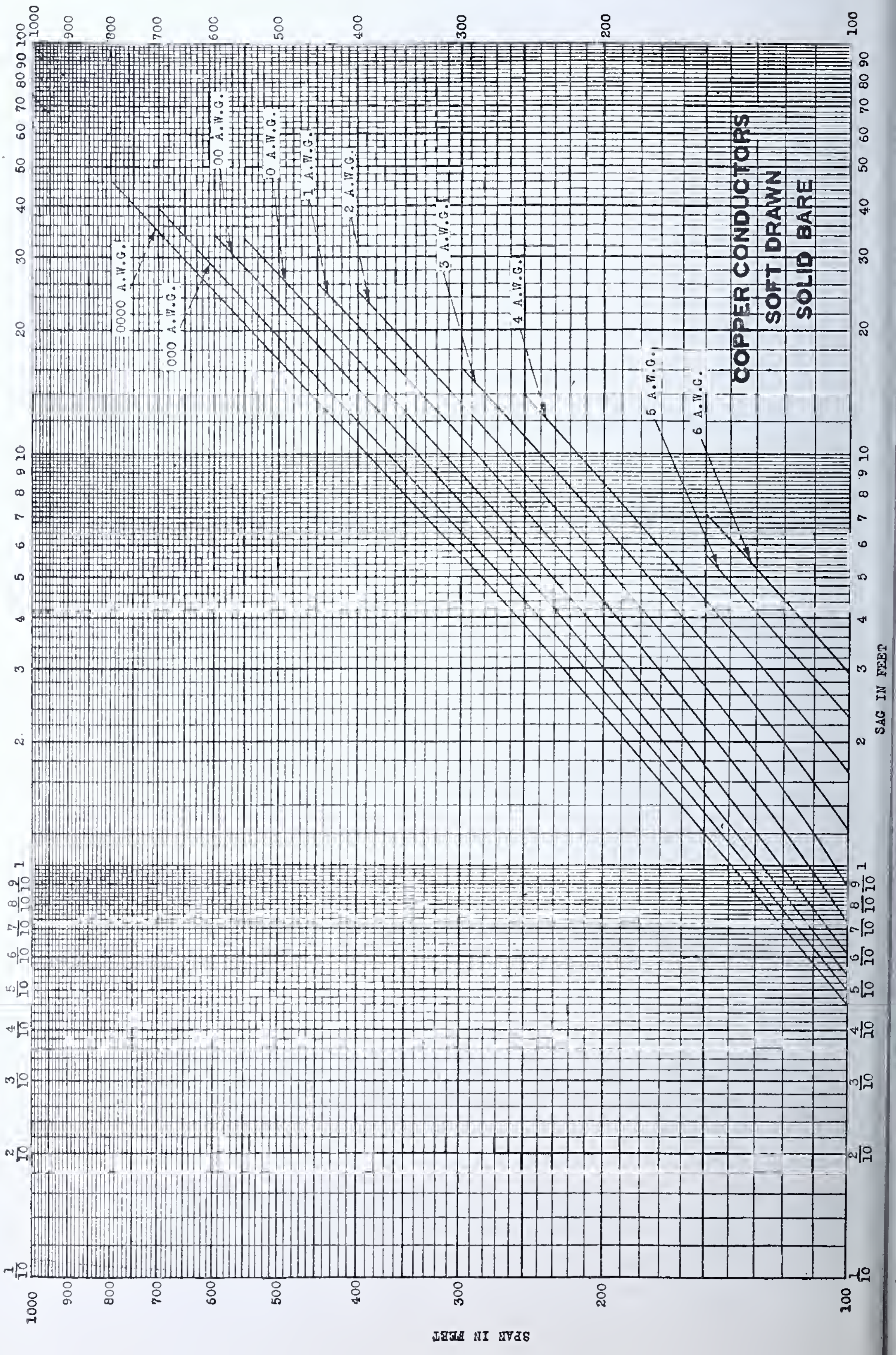
As the span length is 400 ft., and the distance from the nearest support to the point of crossing is 120 ft., this distance is 30 per cent. of the span length. From the curve, Page 116, the value of the sag at this point is 84 per cent. of the centre sag. The sag at this point, therefore, equals 8.9 × .84 = 7.47 ft.

Therefore, the required elevation of the crossing conductor at its point of support is equal to the height of the Class **"C"** wires crossed (25 ft.), plus the minimum vertical clearance required (6.5 ft.), plus the sag of the conductor at the point of crossing (7.47 ft.)

$$25 \text{ ft.} + 6.5 \text{ ft.} + 7.47 \text{ ft.} = 38.97 \text{ ft.}$$

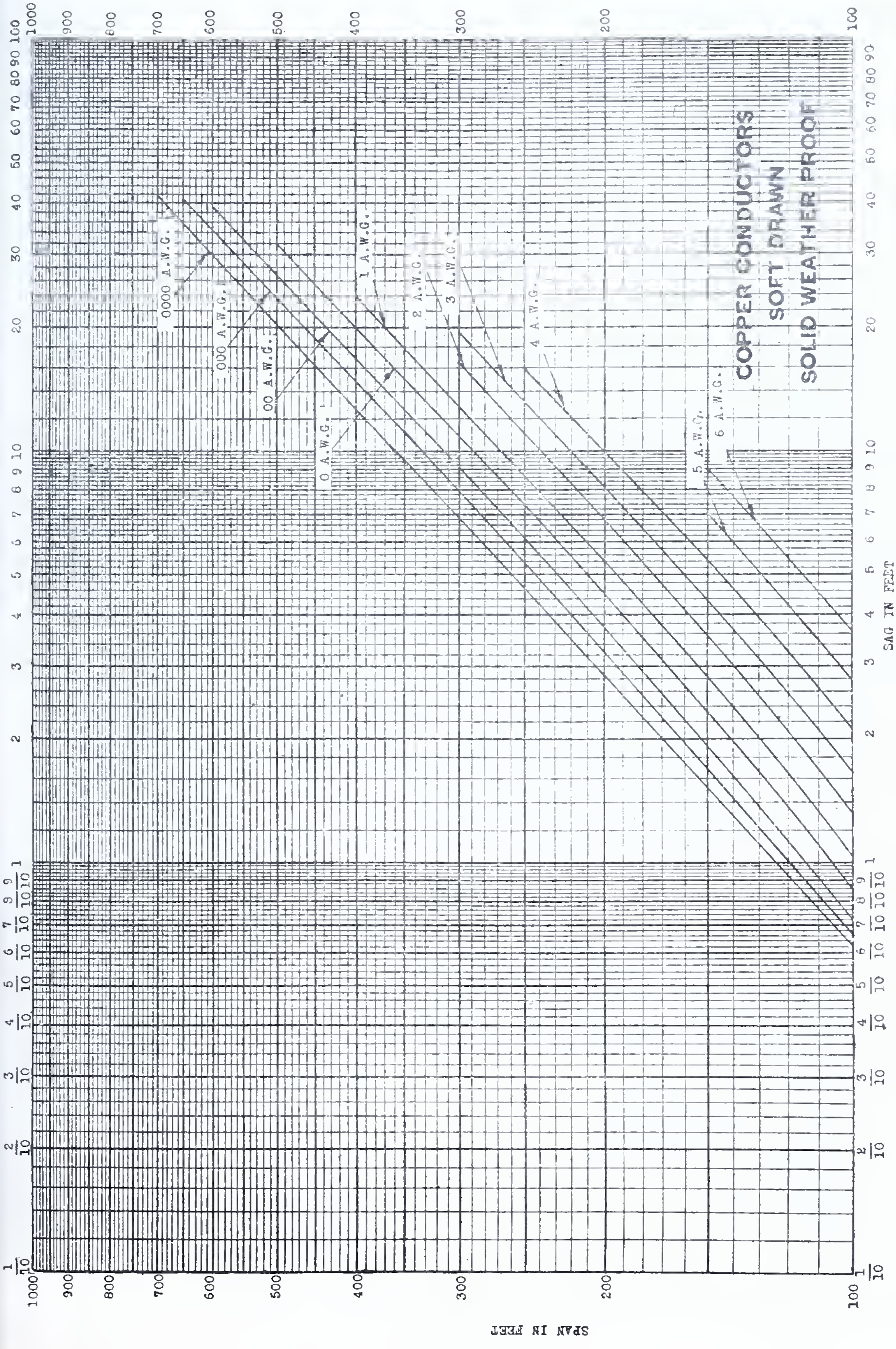
APPENDIX C—Page 6.

Conductor Sags—Copper—Soft Drawn—Solid—Bare.



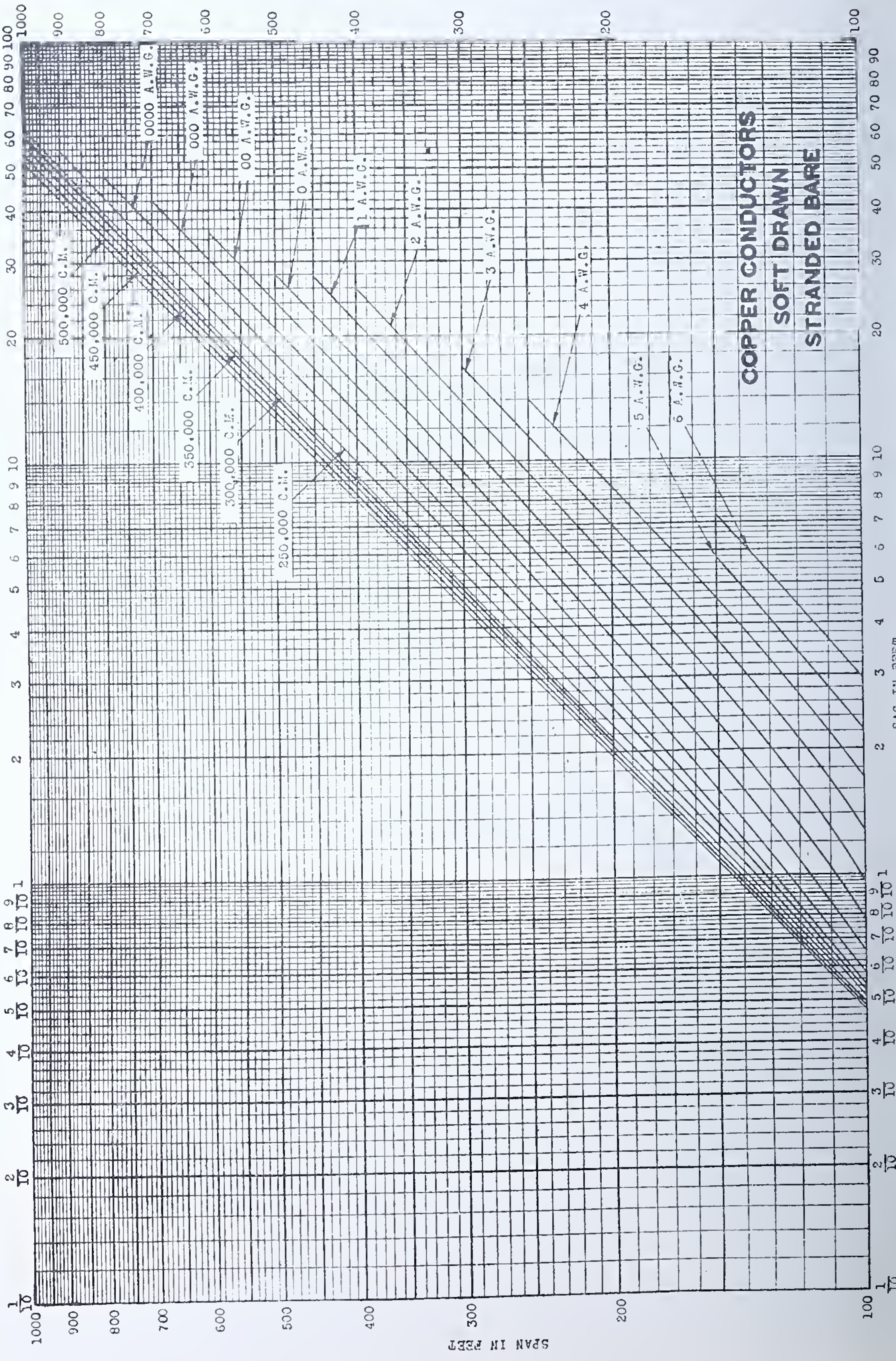
APPENDIX C—Page 7.

Conductor Sags—Copper—Soft Drawn—Solid—Weatherproof.



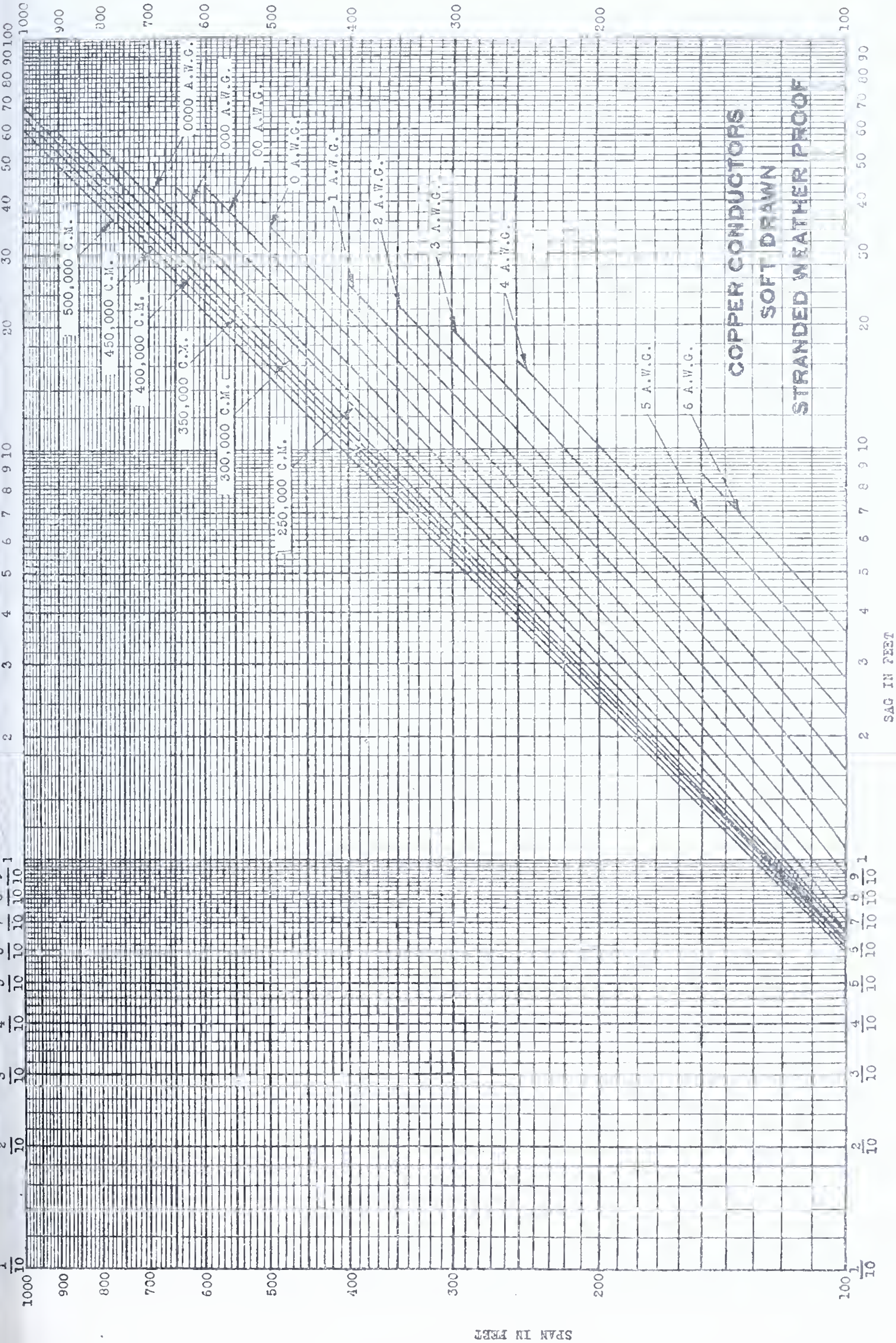
APPENDIX C—Page 8.

Conductor Sags—Copper—Soft Drawn—Stranded—Bare.



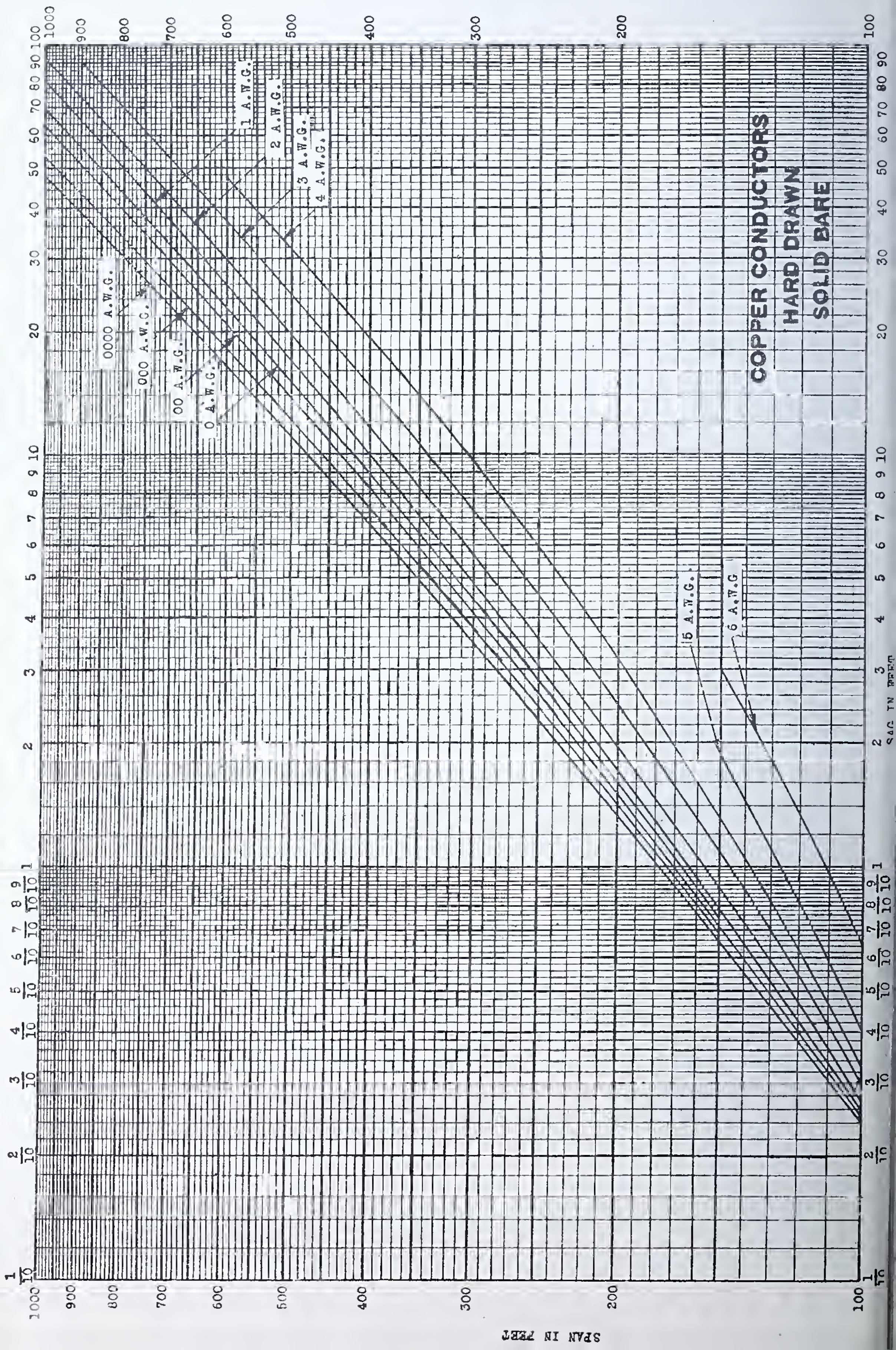
APPENDIX C—Page 9.

Conductor Sags—Copper—Soft Drawn—Stranded—Weatherproof.



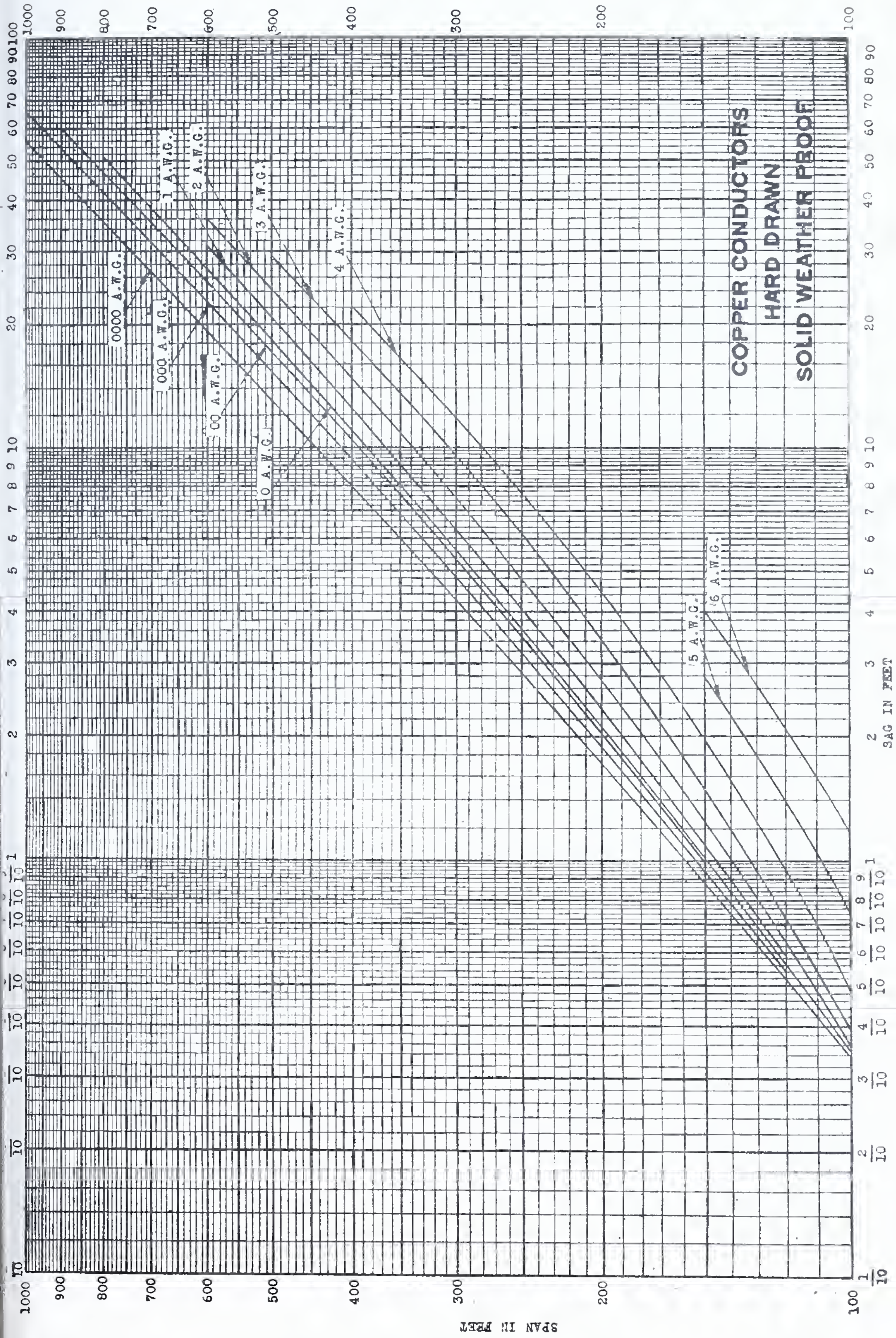
APPENDIX C—Page 10.

Conductor Sags—Copper—Hard Drawn—Solid—Bare.



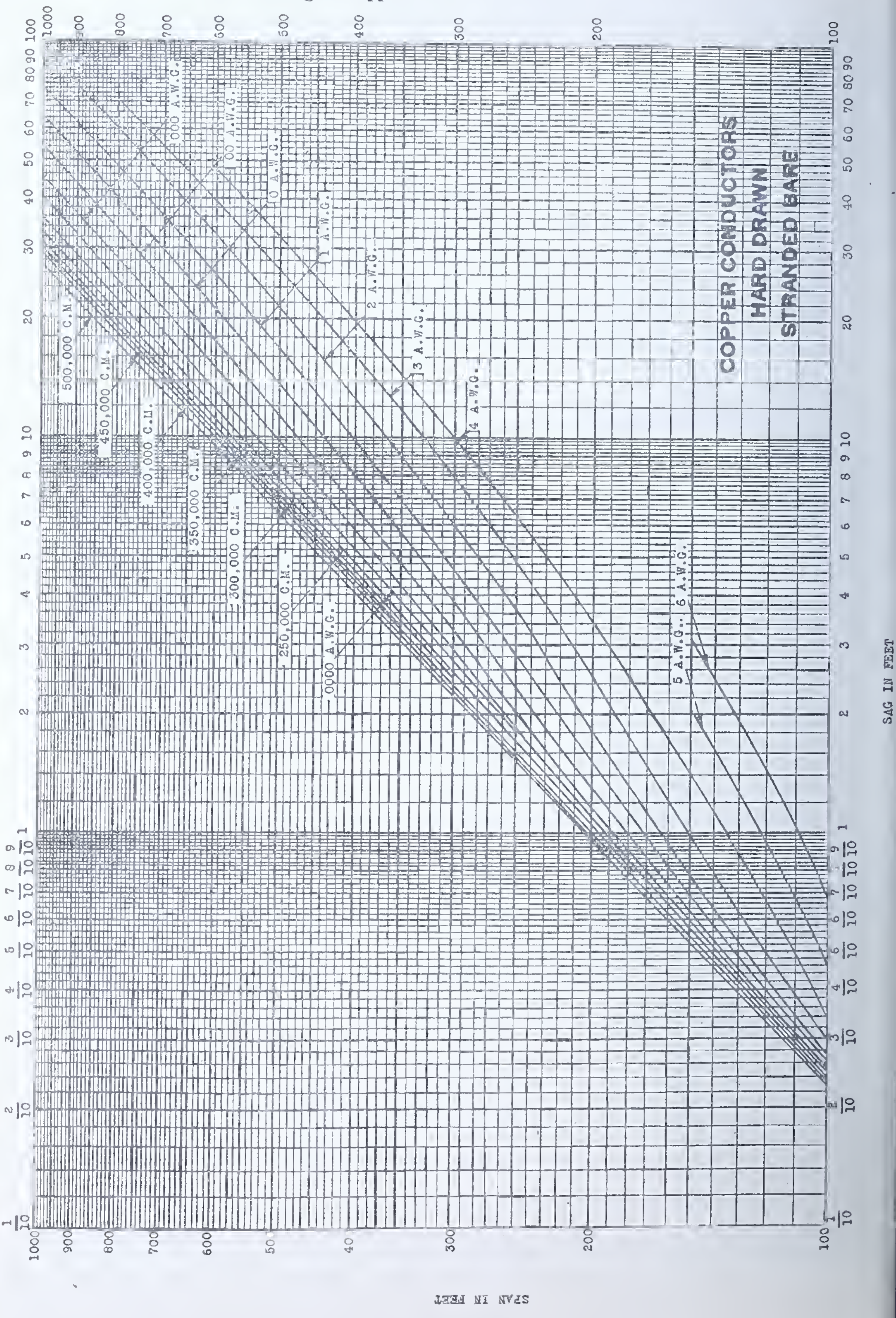
APPENDIX C—Page 11.

Conductor Sags—Copper—Hard Drawn—Solid—Weatherproof.



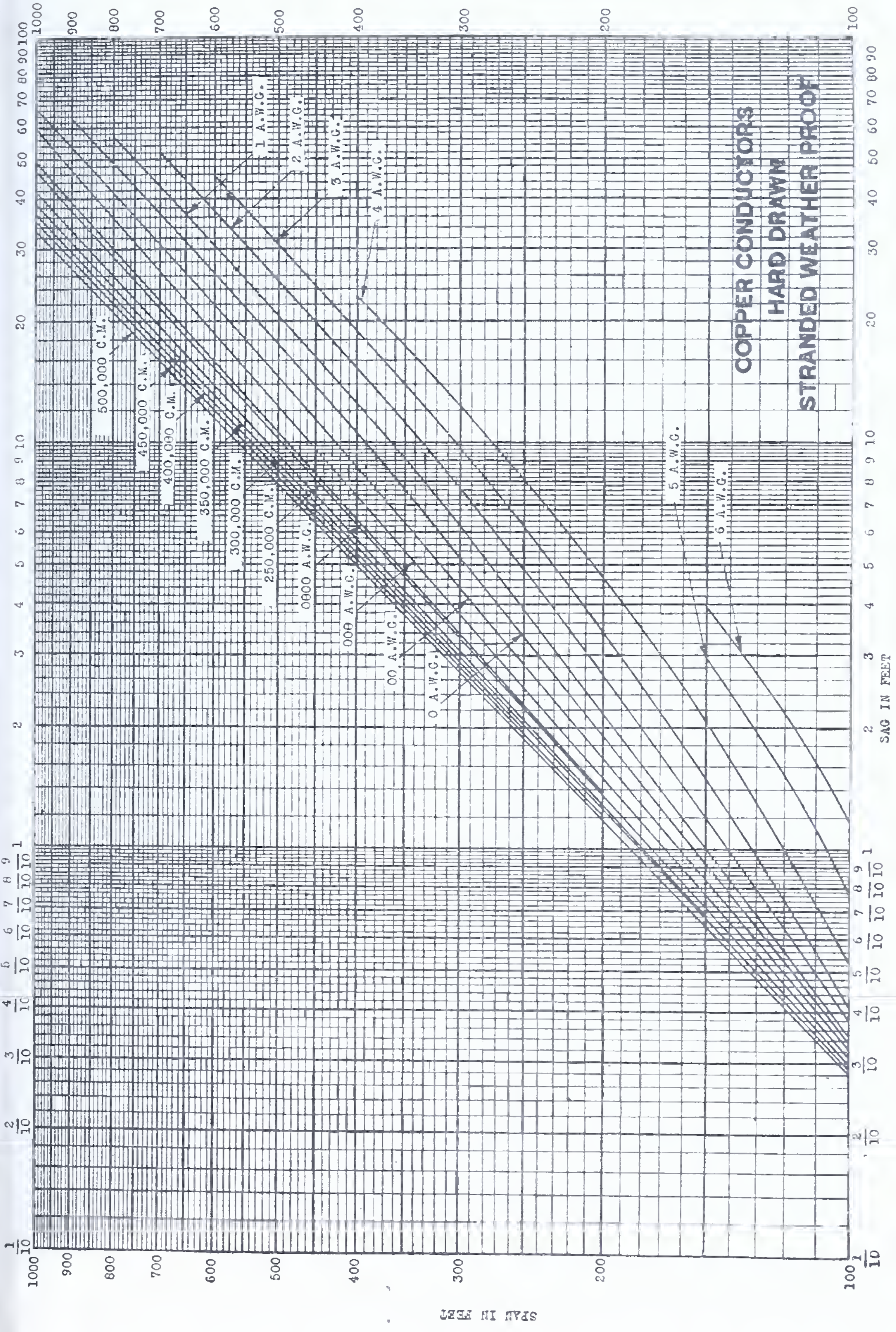
APPENDIX C—Page 12.

Conductor Sags—Copper—Hard Drawn—Stranded—Bare.



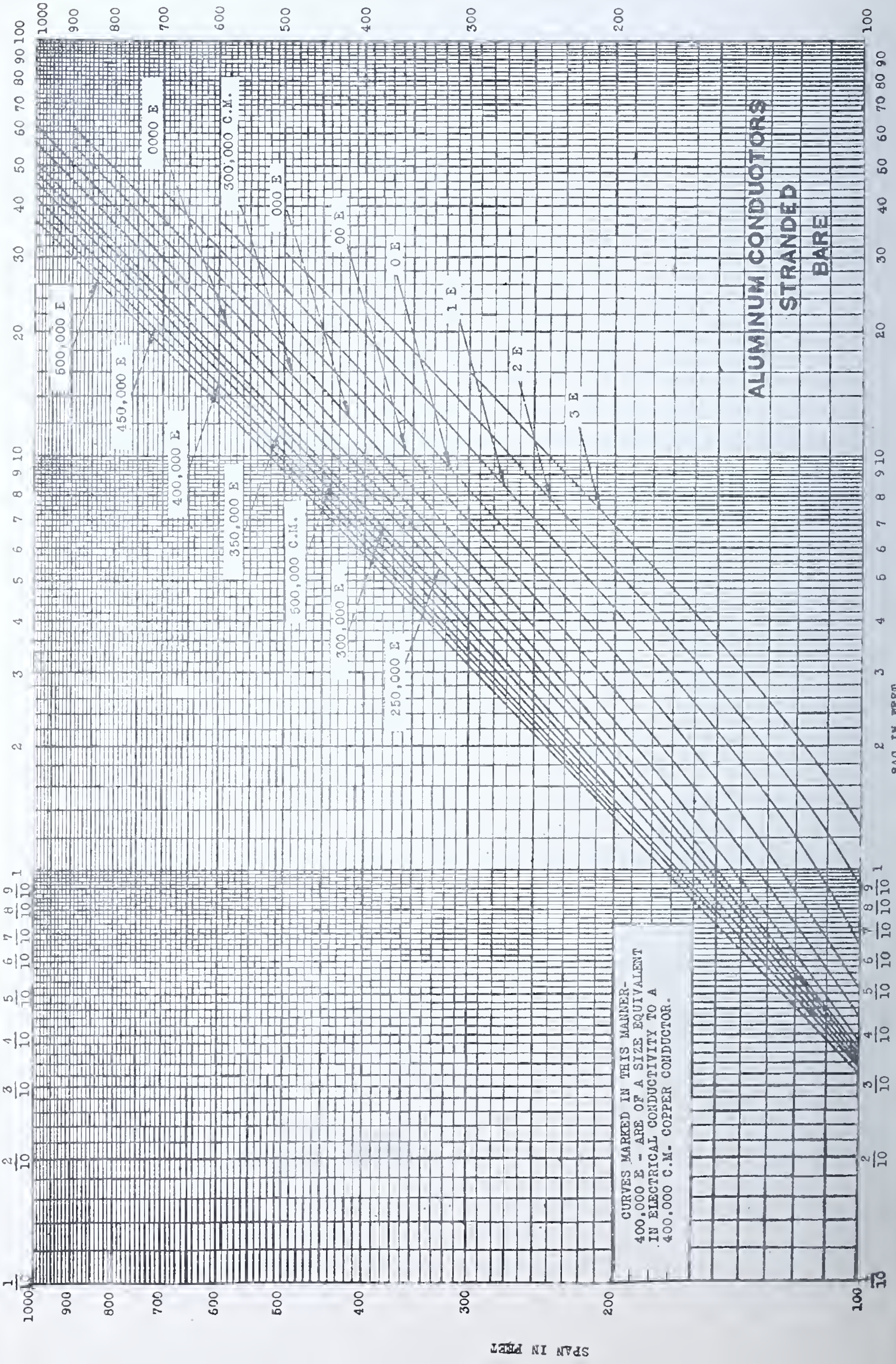
APPENDIX C—Page 13.

Conductor Sags—Copper—Hard Drawn—Stranded—Weatherproof.



APPENDIX C—Page 14.

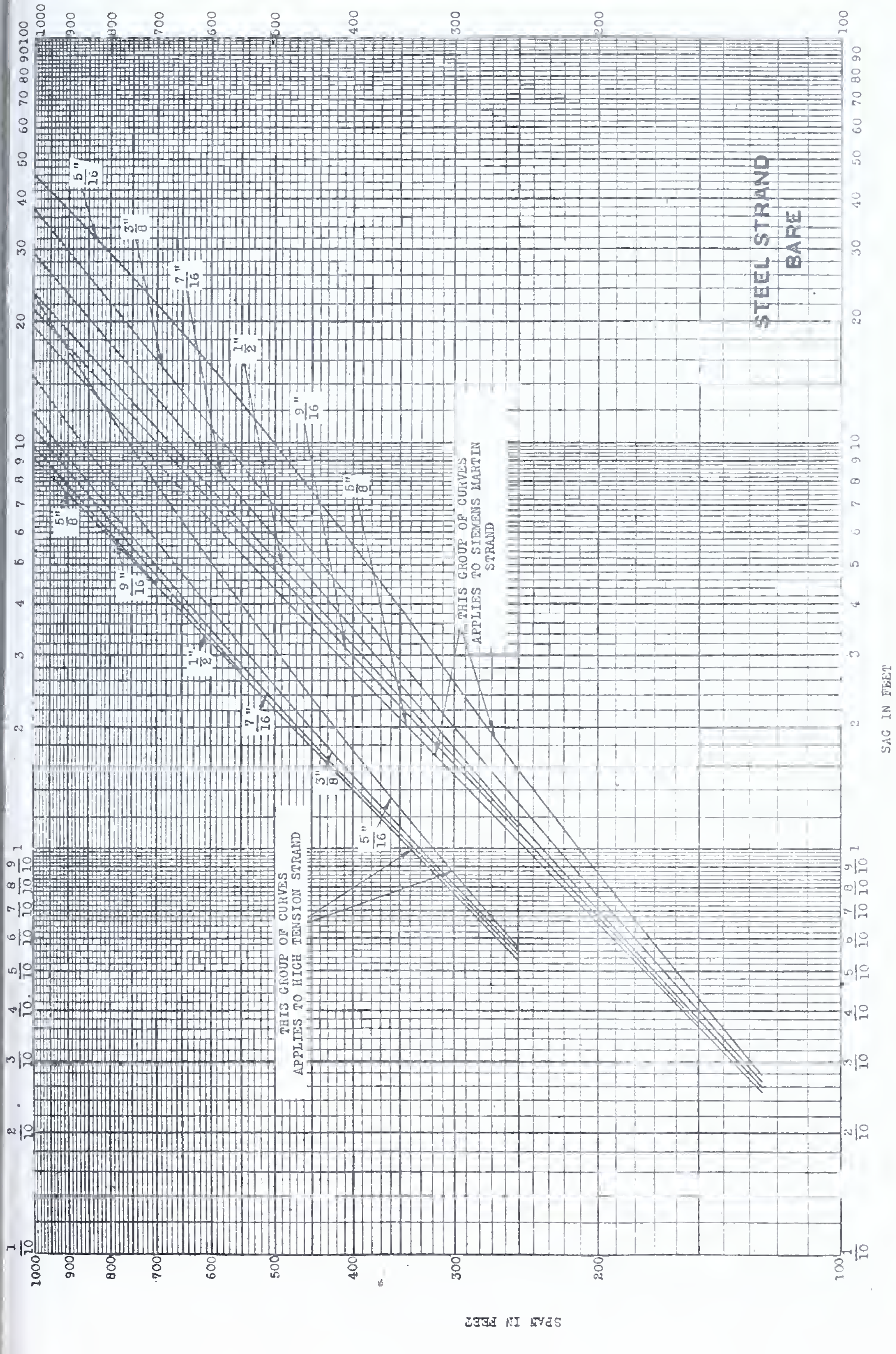
Conductor Sags—Aluminum—Stranded—Bare.



CURVES MARKED IN THIS MANNER- 400,000 E - ARE OF A SIZE EQUIVALENT IN ELECTRICAL CONDUCTIVITY TO A 400.000 C.M. COPPER CONDUCTOR.

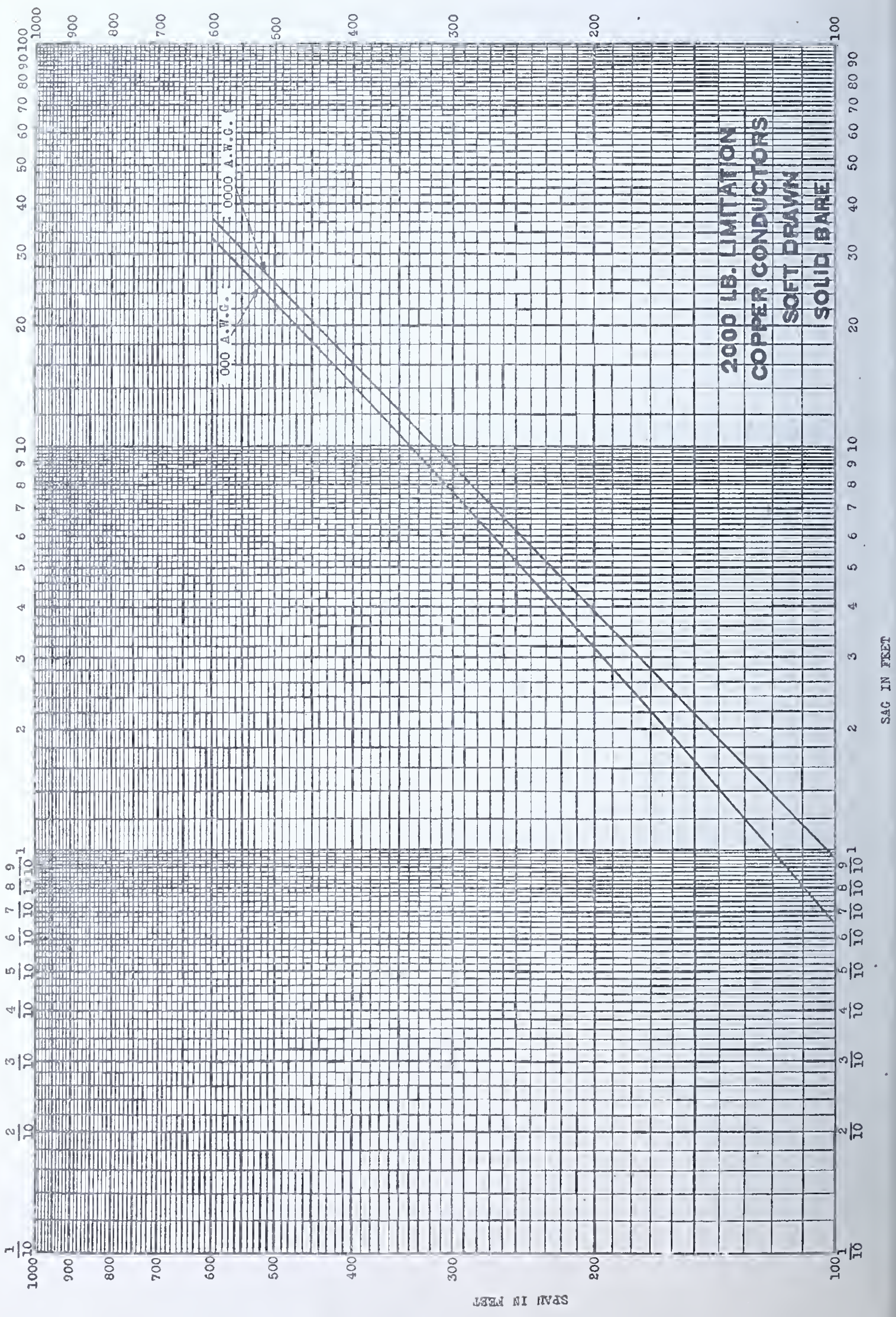
APPENDIX C—Page 15.

Conductor Sags—Steel Strand—Bare.



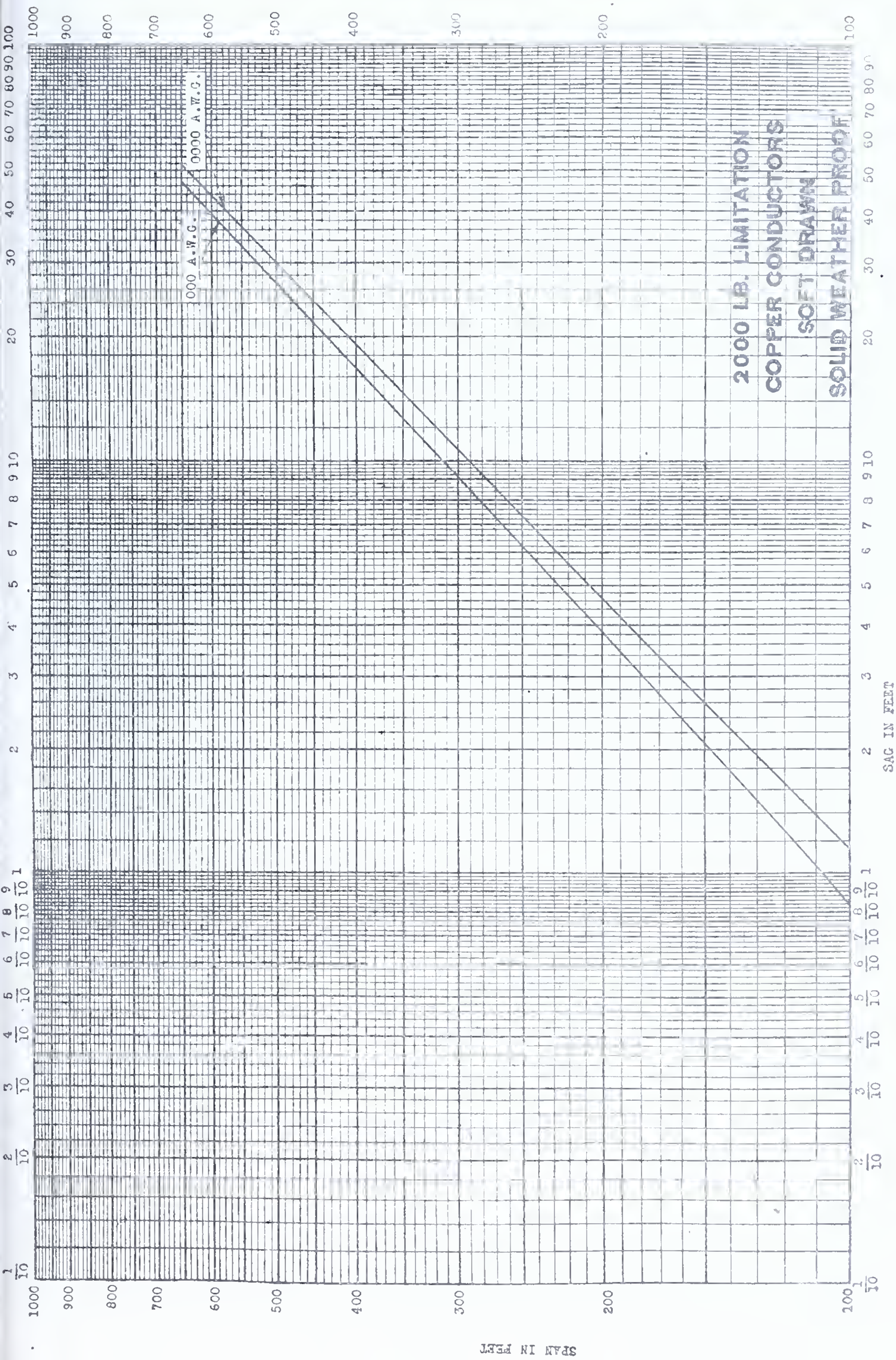
APPENDIX C—Page 16.

Conductor Sags—2000 Lbs. Limitation—Copper—Soft Drawn—Solid—Bare.



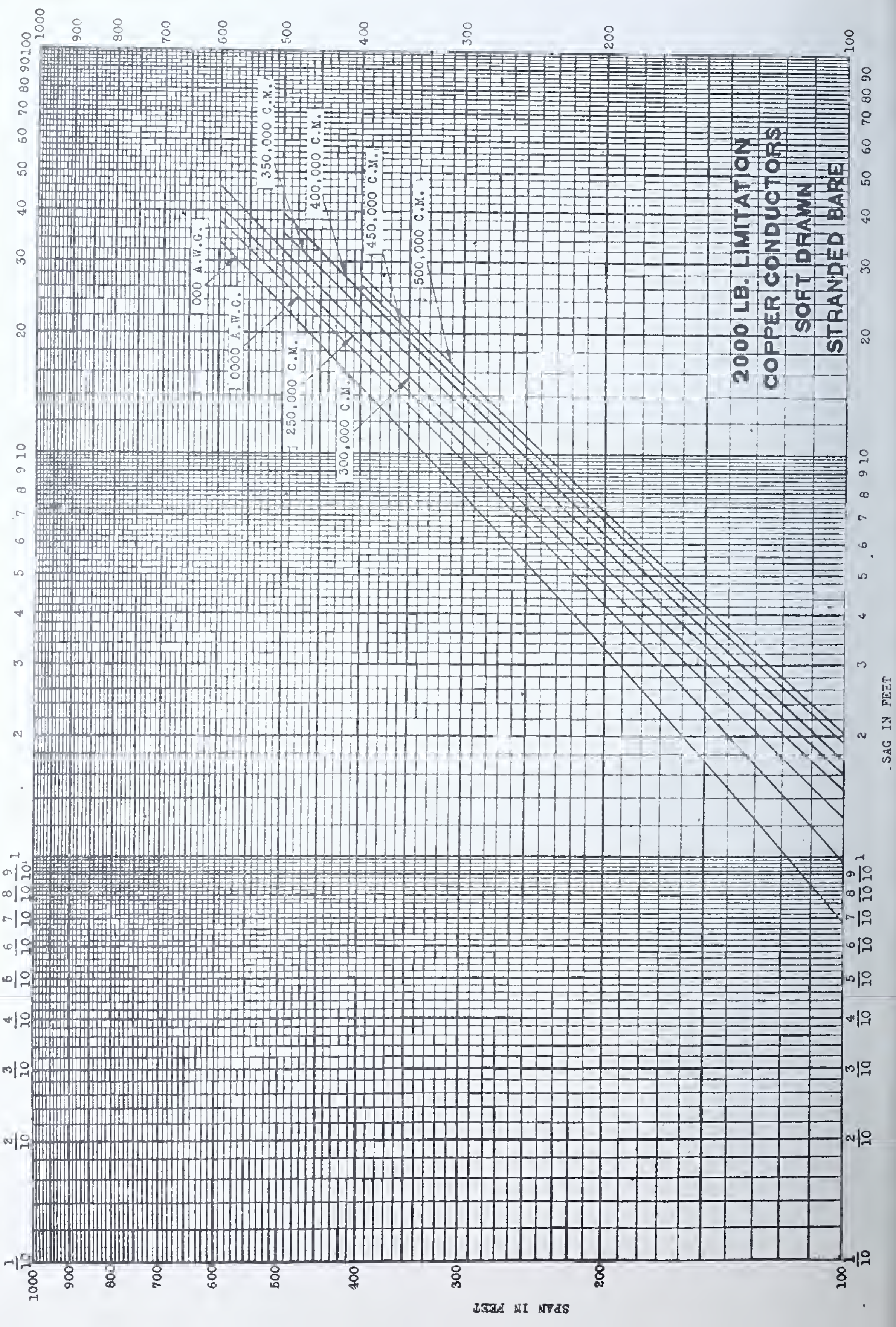
APPENDIX C—Page 17.

Conductor Sags—2000 Lbs. Limitation—Copper Soft Drawn—Solid—Weatherproof.



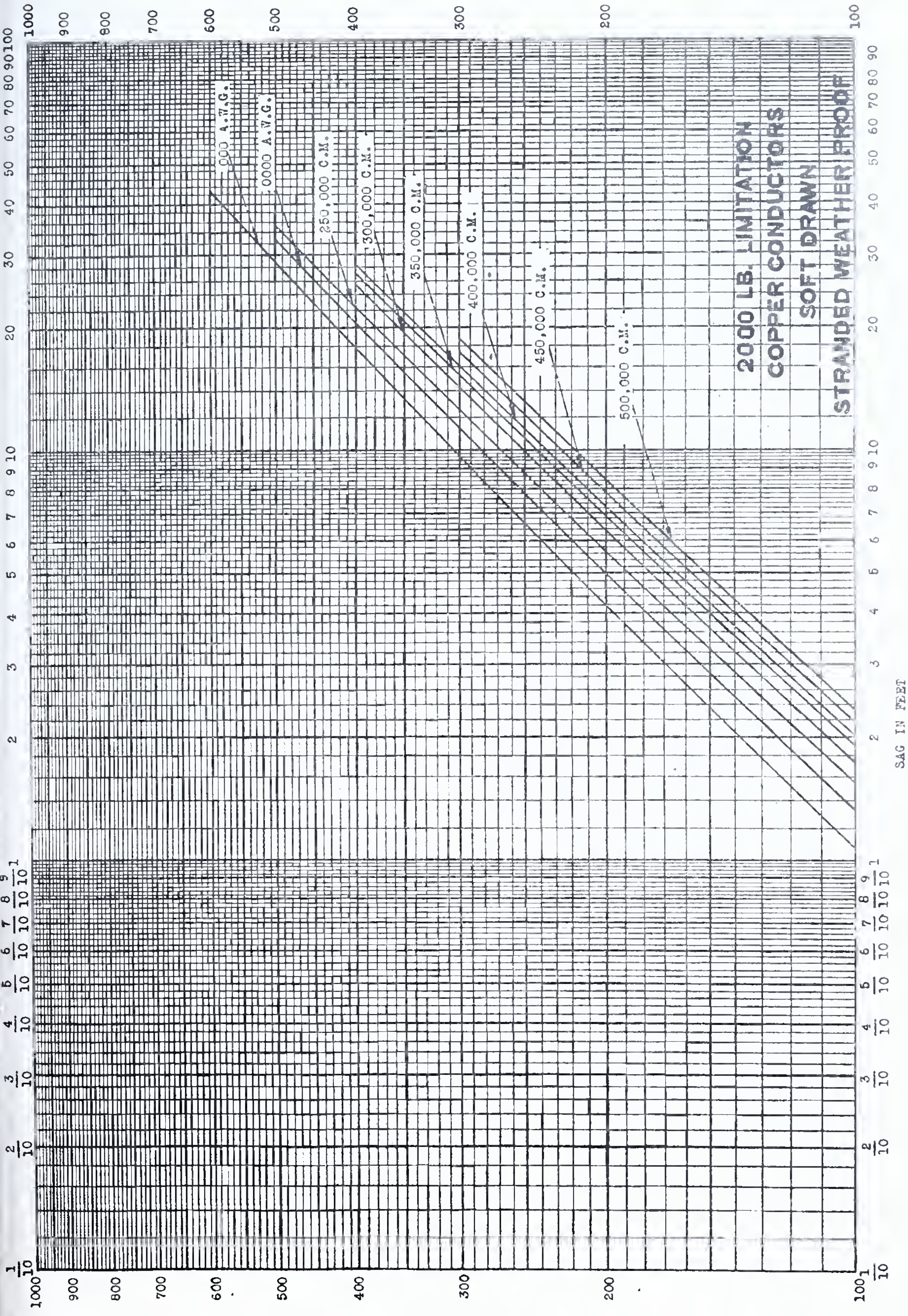
APPENDIX C—Page 18.

Conductor Sags—2000 Lbs. Limitation—Copper—Soft Drawn—Standard—Bare.



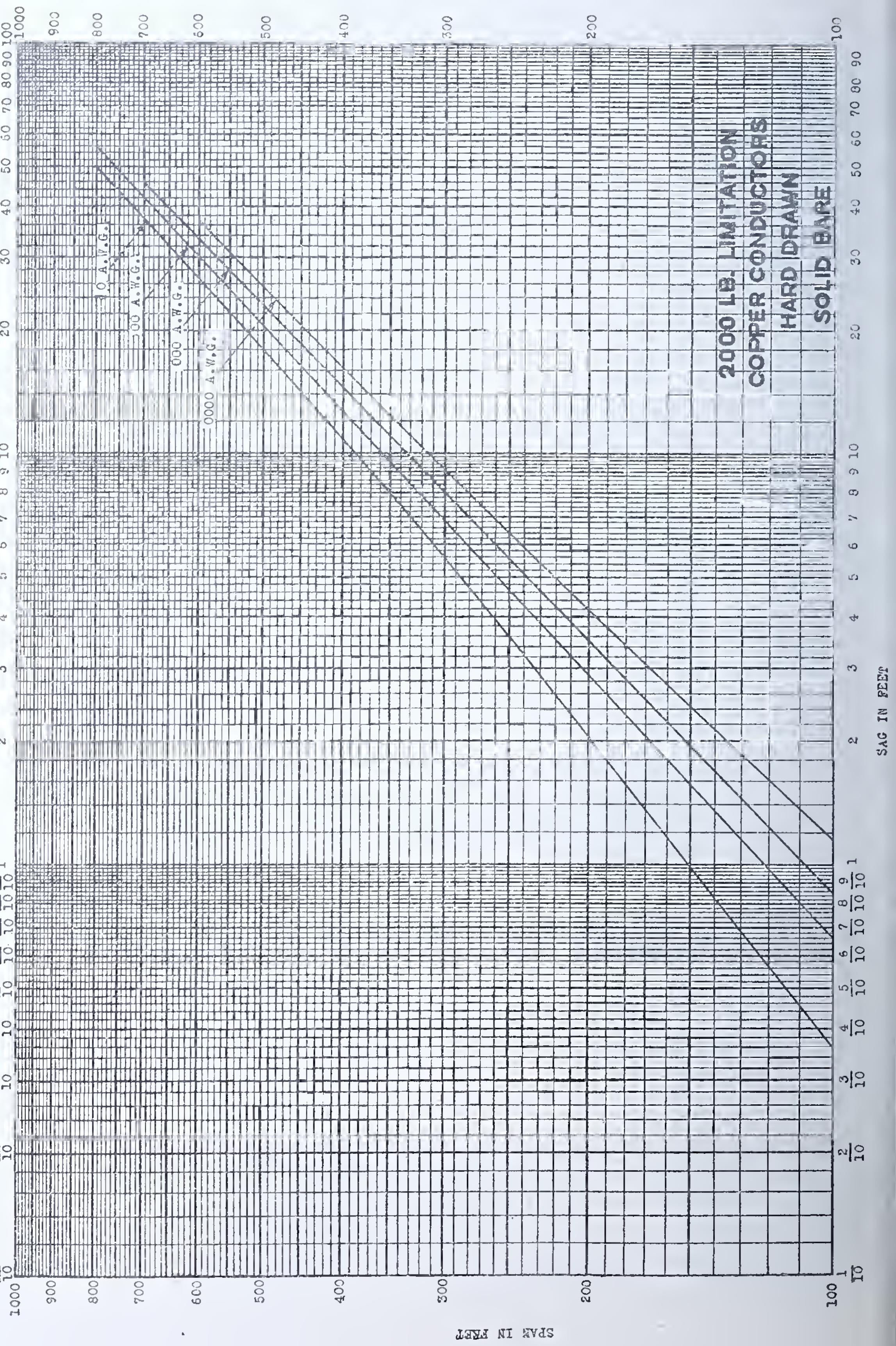
APPENDIX C—Page 19.

Conductor Sags—2000 Lbs. Limitation—Copper—Soft Drawn—Stranded—Weatherproof.



APPENDIX C—Page 20.

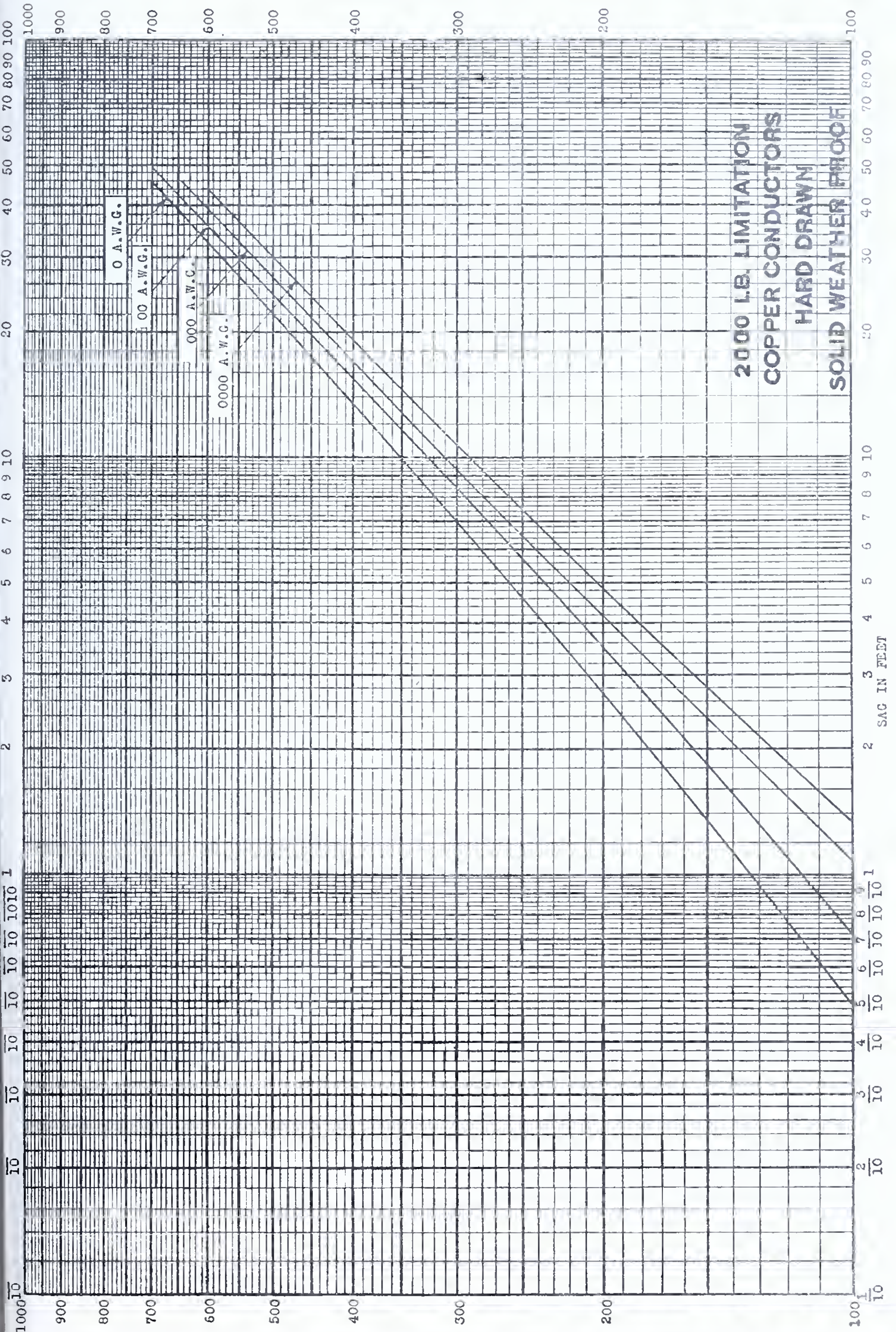
Conductor Sags—2000 Lbs. Limitation—Copper—Hard Drawn—Solid—Bare.



APPENDIX C—Page 21.

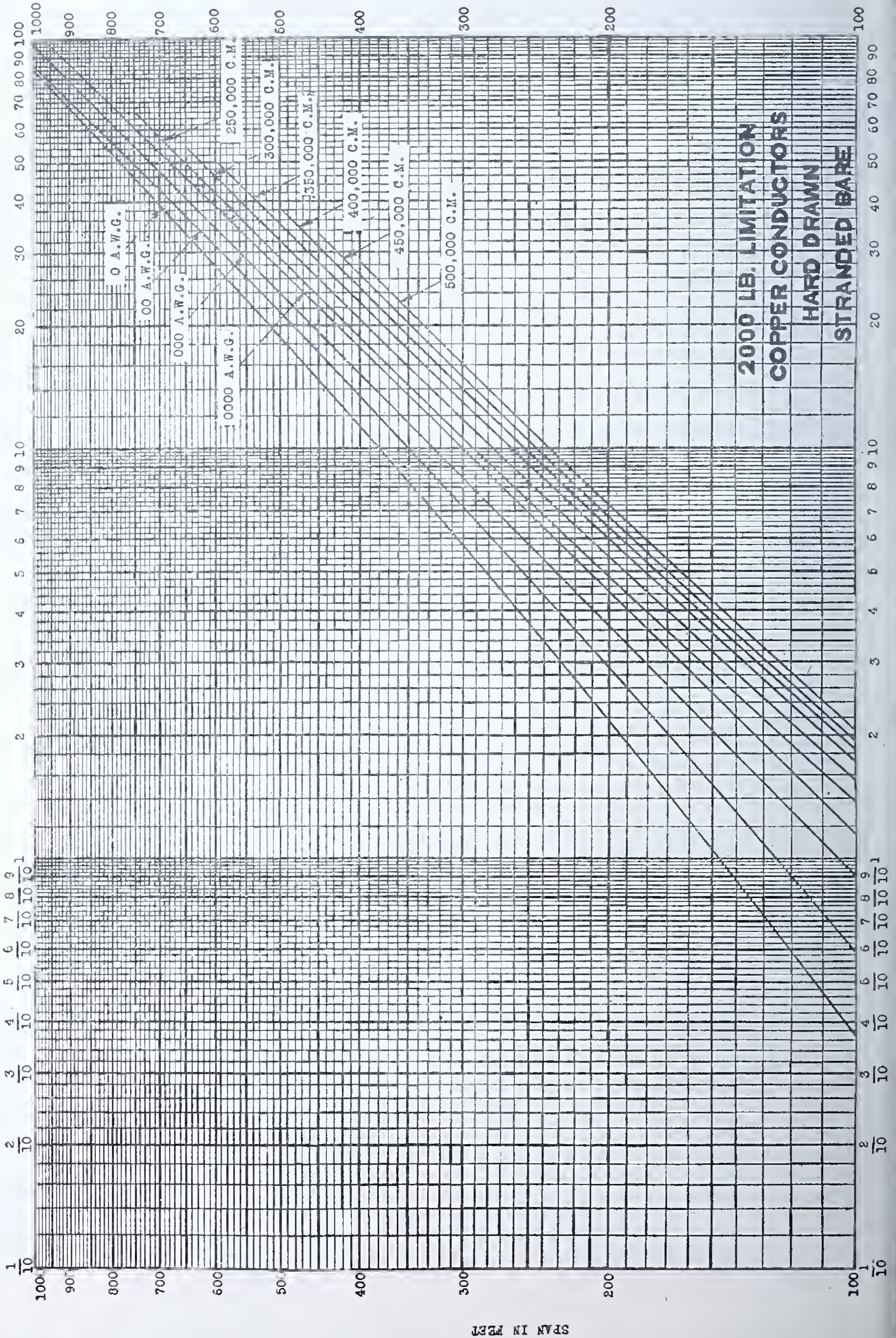
Solid—Weatherproof.

Conductors Sags—2000 Lbs. Limitation—Copper—Hard Drawn—



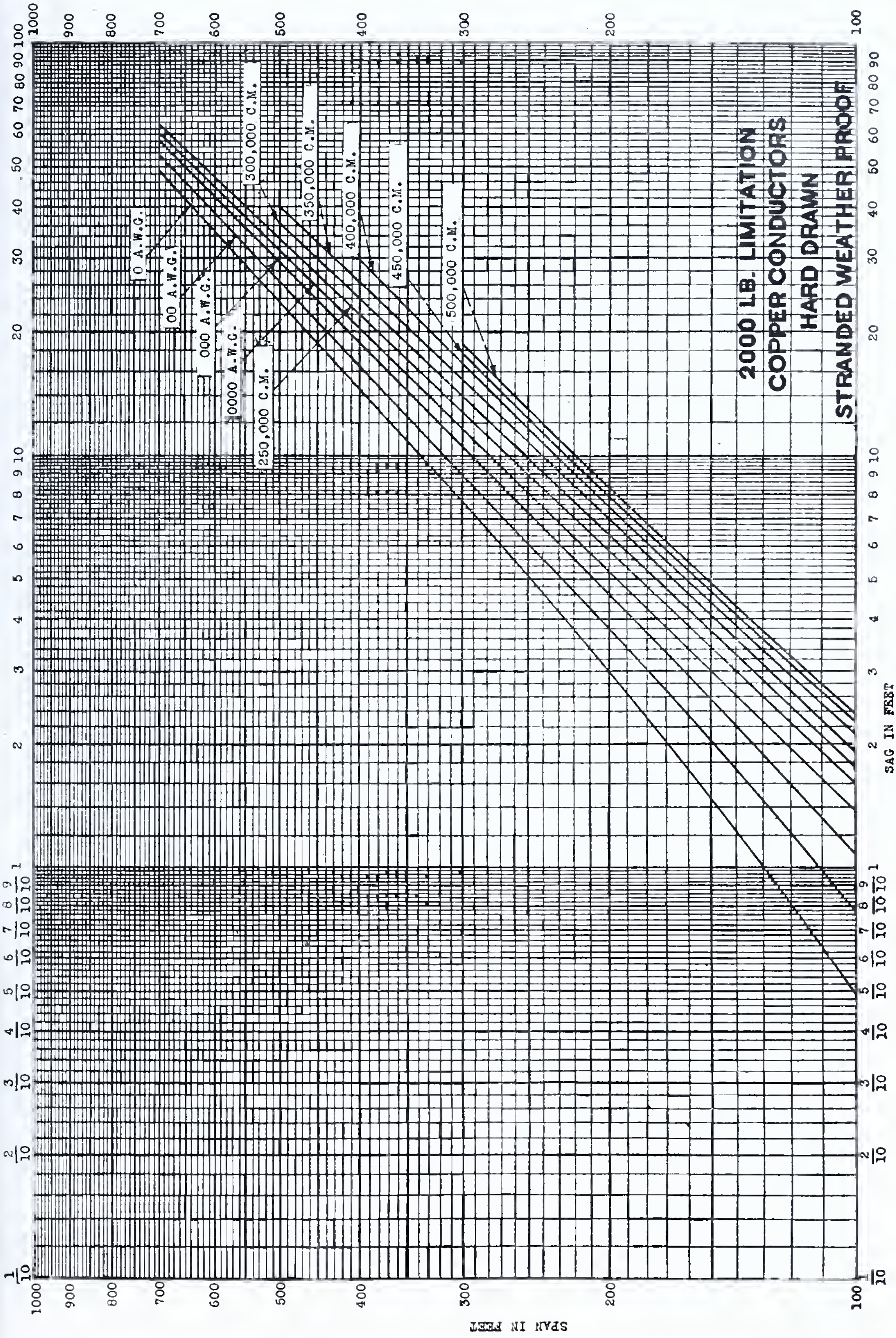
APPENDIX C—Page 22.

Conductor Sags—2000 Lbs. Limitation—Copper—Hard Drawn—Stranded—Bare.



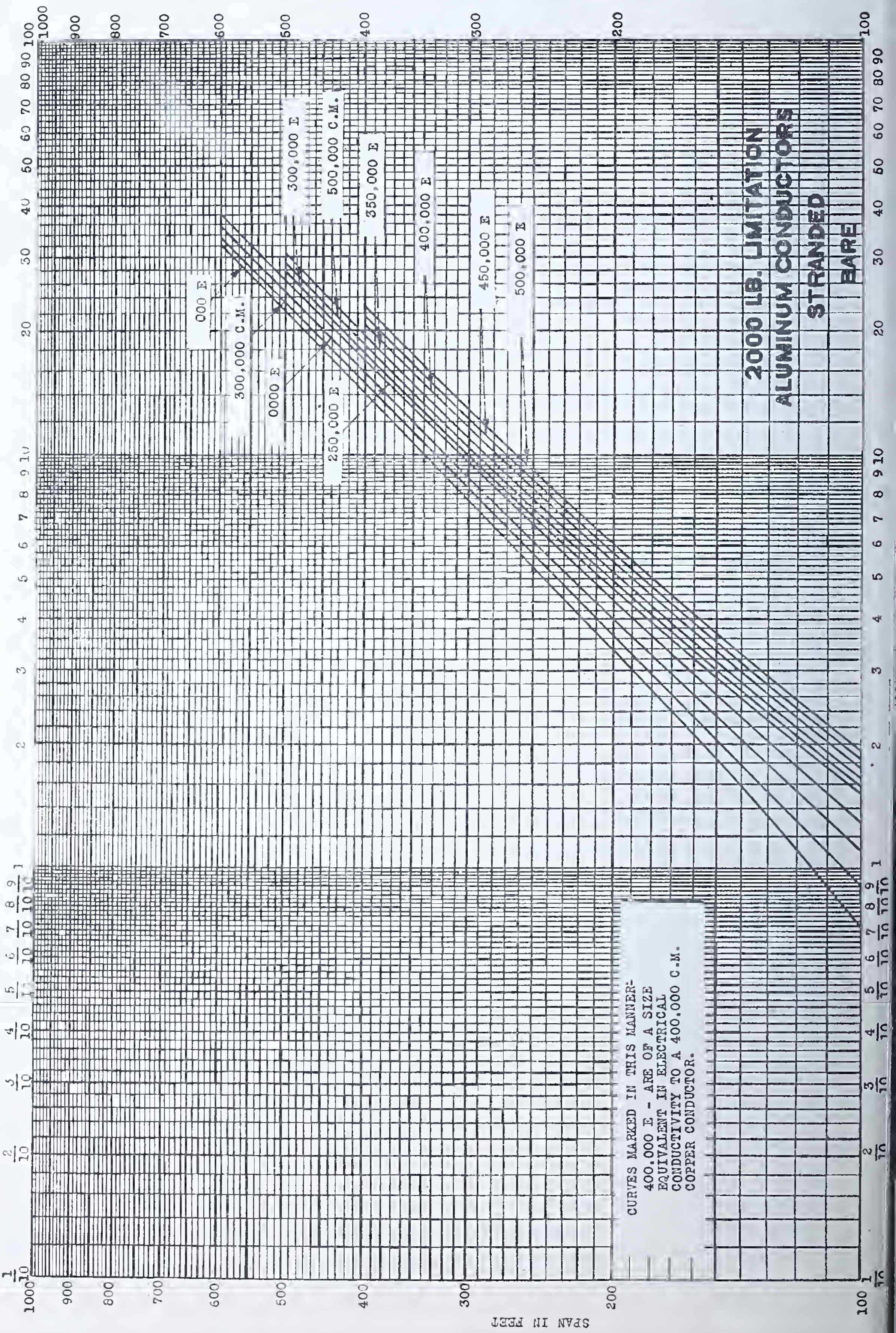
APPENDIX C—Page 23.

Conductor Sags—2000 Lbs. Limitation—Copper—Hard Drawn—Stranded—Weatherproof.



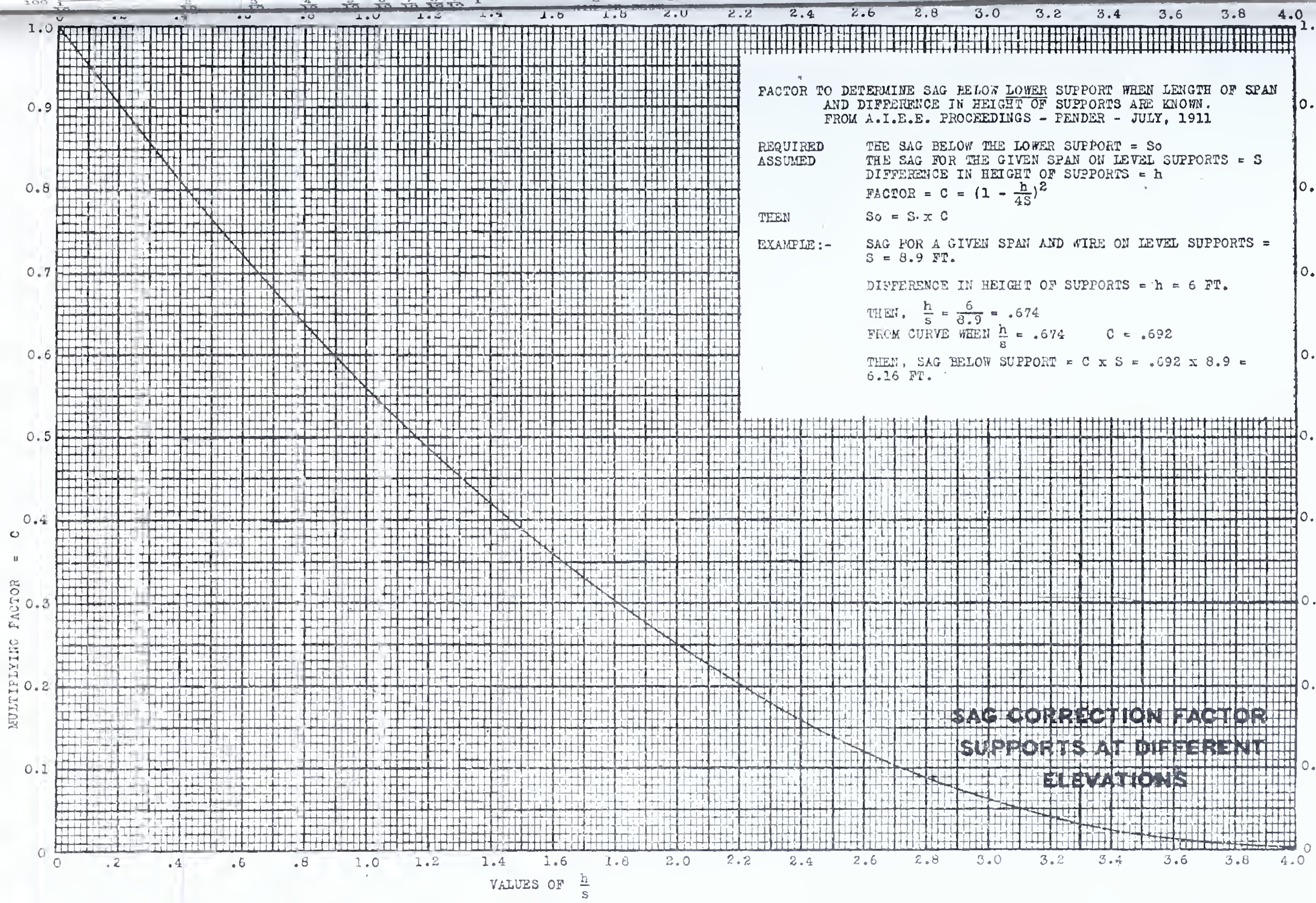
APPENDIX C—Page 24.

Conductor Sags—2000 Lbs. Limitation—Aluminum—Stranded—Bare.



APPENDIX C—Page 25.

Sag Correction Factor—Supports at Different Elevations.



FACTOR TO DETERMINE SAG BELOW LOWER SUPPORT WHEN LENGTH OF SPAN AND DIFFERENCE IN HEIGHT OF SUPPORTS ARE KNOWN.
FROM A.I.E.E. PROCEEDINGS - PENDER - JULY, 1911

REQUIRED THE SAG BELOW THE LOWER SUPPORT = So
ASSUMED THE SAG FOR THE GIVEN SPAN ON LEVEL SUPPORTS = S
DIFFERENCE IN HEIGHT OF SUPPORTS = h
FACTOR = $C = (1 - \frac{h}{4S})^2$

THEN So = S x C

EXAMPLE:- SAG FOR A GIVEN SPAN AND WIRE ON LEVEL SUPPORTS = S = 8.9 FT.

DIFFERENCE IN HEIGHT OF SUPPORTS = h = 6 FT.

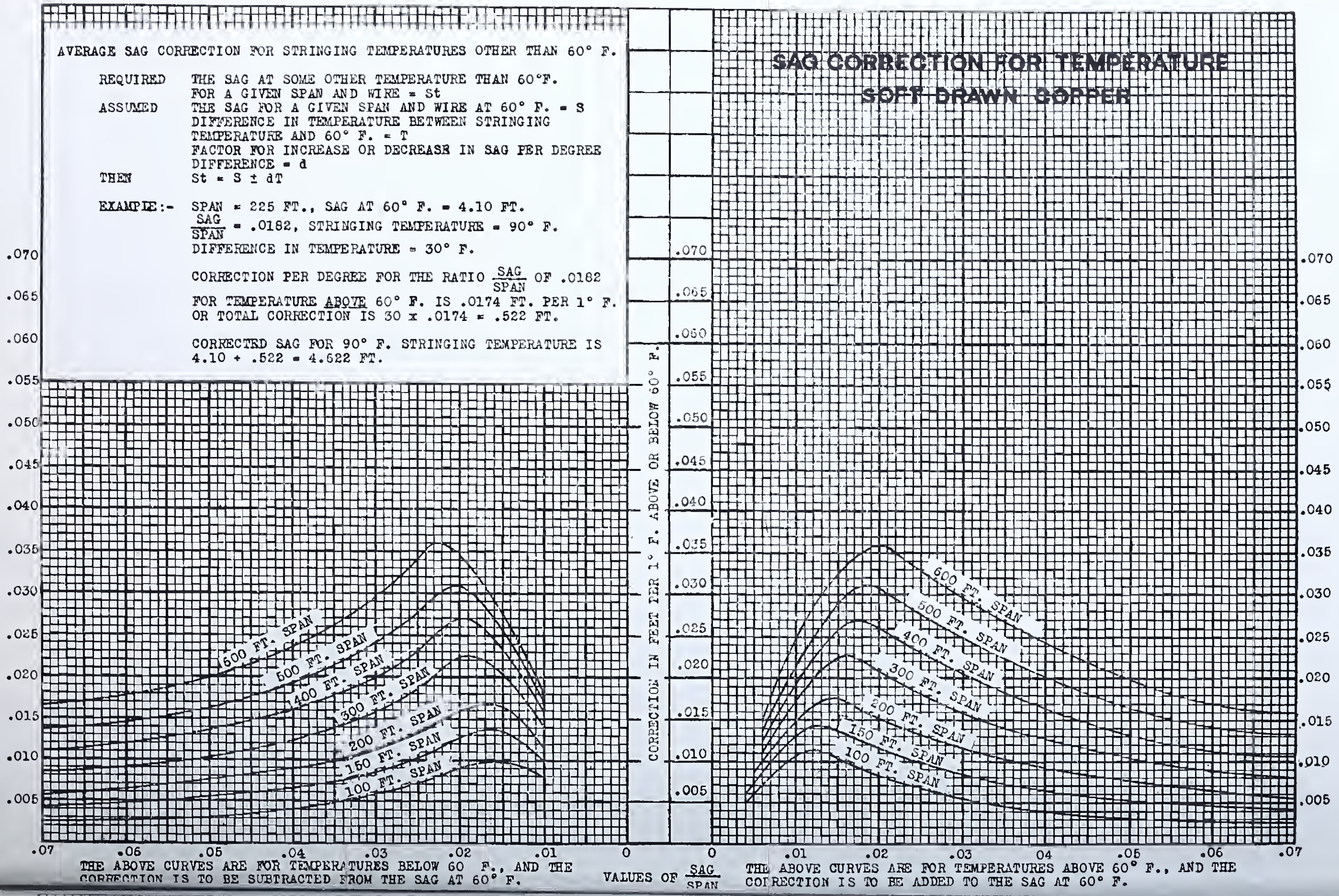
THEN, $\frac{h}{s} = \frac{6}{8.9} = .674$

FROM CURVE WHEN $\frac{h}{s} = .674$ C = .692

THEN, SAG BELOW SUPPORT = C x S = .692 x 8.9 = 6.16 FT.

APPENDIX C—Page 26.

Sag Correction for Temperature—Copper—Soft Drawn.



THE ABOVE CURVES ARE FOR TEMPERATURES BELOW 60 F., AND THE CORRECTION IS TO BE SUBTRACTED FROM THE SAG AT 60° F.

THE ABOVE CURVES ARE FOR TEMPERATURES ABOVE 60° F., AND THE CORRECTION IS TO BE ADDED TO THE SAG AT 60° F.

AVERAGE SAG CORRECTION FOR STRINGING TEMPERATURES OTHER THAN 60° F.

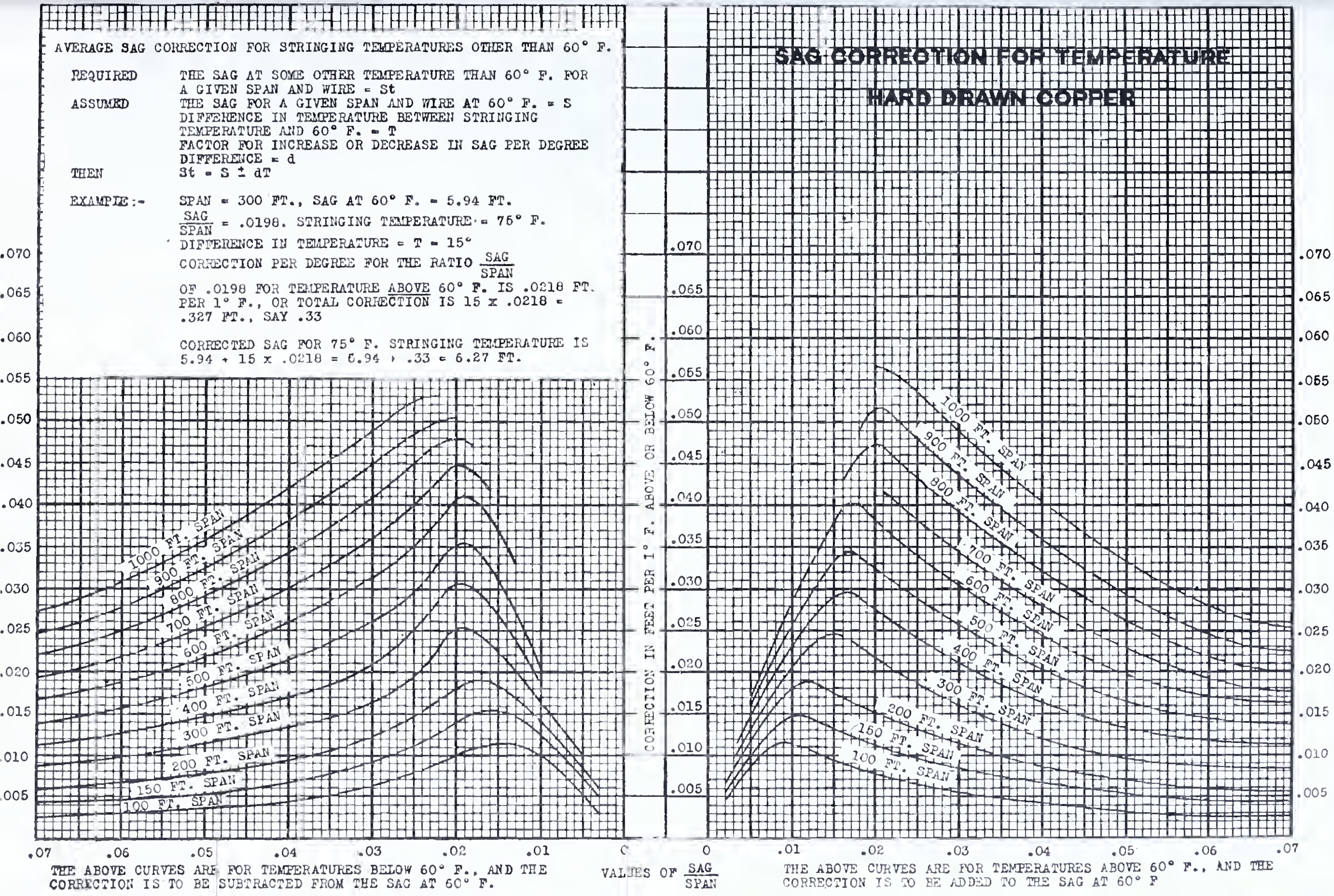
REQUIRED	THE SAG AT SOME OTHER TEMPERATURE THAN 60°F. FOR A GIVEN SPAN AND WIRE = St
ASSUMED	THE SAG FOR A GIVEN SPAN AND WIRE AT 60° F. = S DIFFERENCE IN TEMPERATURE BETWEEN STRINGING TEMPERATURE AND 60° F. = T FACTOR FOR INCREASE OR DECREASE IN SAG PER DEGREE DIFFERENCE = d
THEN	St = S ± dT
EXAMPLE:-	SPAN = 225 FT., SAG AT 60° F. = 4.10 FT. $\frac{\text{SAG}}{\text{SPAN}}$ = .0182, STRINGING TEMPERATURE = 90° F. DIFFERENCE IN TEMPERATURE = 30° F.

CORRECTION PER DEGREE FOR THE RATIO $\frac{\text{SAG}}{\text{SPAN}}$ OF .0182 FOR TEMPERATURE ABOVE 60° F. IS .0174 FT. PER 1° F. OR TOTAL CORRECTION IS 30 x .0174 = .522 FT.

CORRECTED SAG FOR 90° F. STRINGING TEMPERATURE IS 4.10 + .522 = 4.622 FT.

APPENDIX C—Page 27.

Sag Correction for Temperature—Copper—Hard Drawn.



AVERAGE SAG CORRECTION FOR STRINGING TEMPERATURES OTHER THAN 60° F.

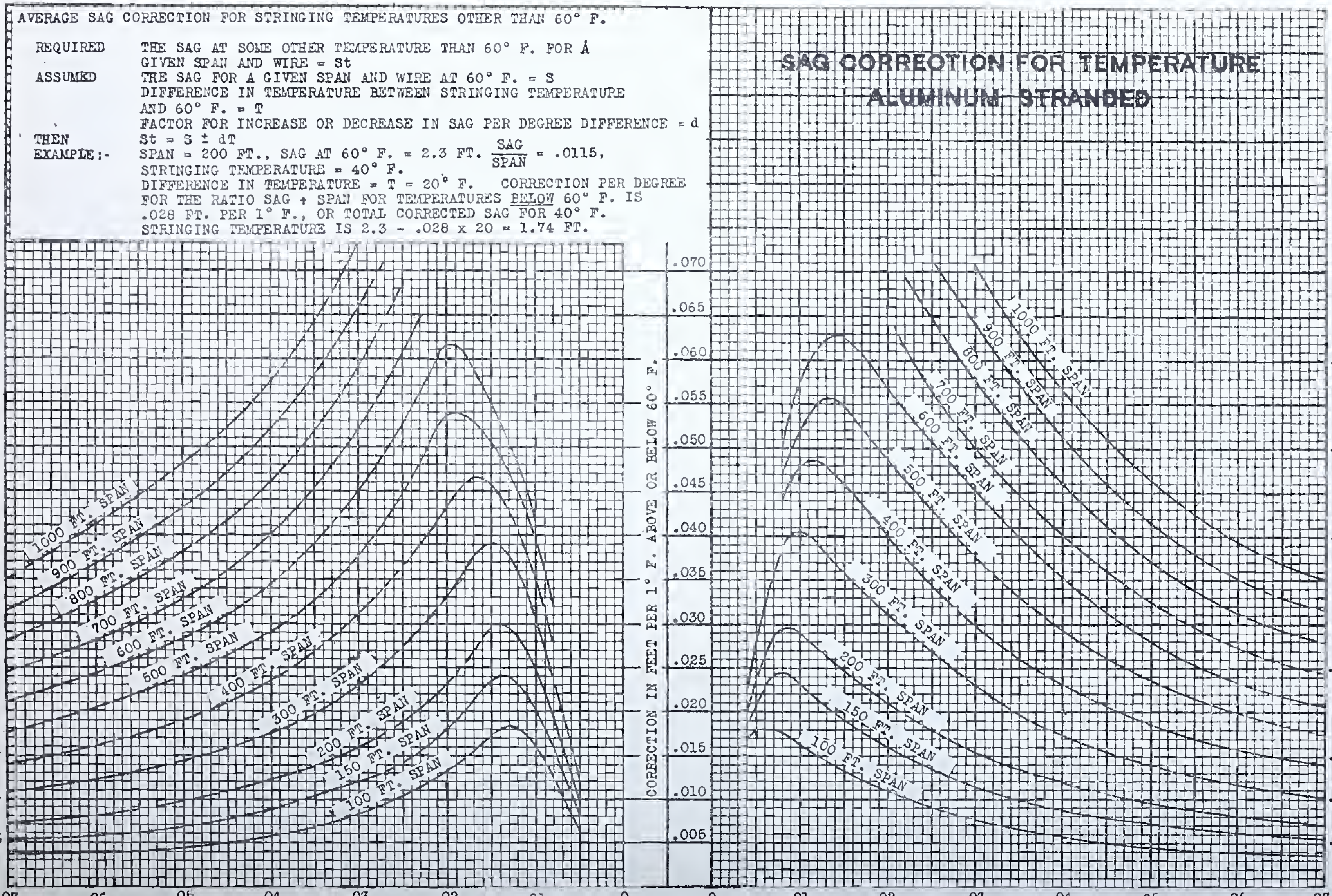
REQUIRED	THE SAG AT SOME OTHER TEMPERATURE THAN 60° F. FOR A GIVEN SPAN AND WIRE = St
ASSUMED	THE SAG FOR A GIVEN SPAN AND WIRE AT 60° F. = S DIFFERENCE IN TEMPERATURE BETWEEN STRINGING TEMPERATURE AND 60° F. = T FACTOR FOR INCREASE OR DECREASE IN SAG PER DEGREE DIFFERENCE = d
THEN	St = S ± dT
EXAMPLE:-	SPAN = 300 FT., SAG AT 60° F. = 5.94 FT. $\frac{\text{SAG}}{\text{SPAN}}$ = .0198. STRINGING TEMPERATURE = 75° F. DIFFERENCE IN TEMPERATURE = T = 15° CORRECTION PER DEGREE FOR THE RATIO $\frac{\text{SAG}}{\text{SPAN}}$ OF .0198 FOR TEMPERATURE ABOVE 60° F. IS .0218 FT. PER 1° F., OR TOTAL CORRECTION IS 15 x .0218 = .327 FT., SAY .33 CORRECTED SAG FOR 75° F. STRINGING TEMPERATURE IS 5.94 + 15 x .0218 = 6.94 + .33 = 6.27 FT.

THE ABOVE CURVES ARE FOR TEMPERATURES BELOW 60° F., AND THE CORRECTION IS TO BE SUBTRACTED FROM THE SAG AT 60° F.

THE ABOVE CURVES ARE FOR TEMPERATURES ABOVE 60° F., AND THE CORRECTION IS TO BE ADDED TO THE SAG AT 60° F

APPENDIX C—Page 28.

Sag Correction for Temperature—Aluminum—Stranded.



AVERAGE SAG CORRECTION FOR STRINGING TEMPERATURES OTHER THAN 60° F.

REQUIRED THE SAG AT SOME OTHER TEMPERATURE THAN 60° F. FOR A GIVEN SPAN AND WIRE = St

ASSUMED THE SAG FOR A GIVEN SPAN AND WIRE AT 60° F. = S

DIFFERENCE IN TEMPERATURE BETWEEN STRINGING TEMPERATURE AND 60° F. = T

FACTOR FOR INCREASE OR DECREASE IN SAG PER DEGREE DIFFERENCE = d

THEN $St = S \pm dT$

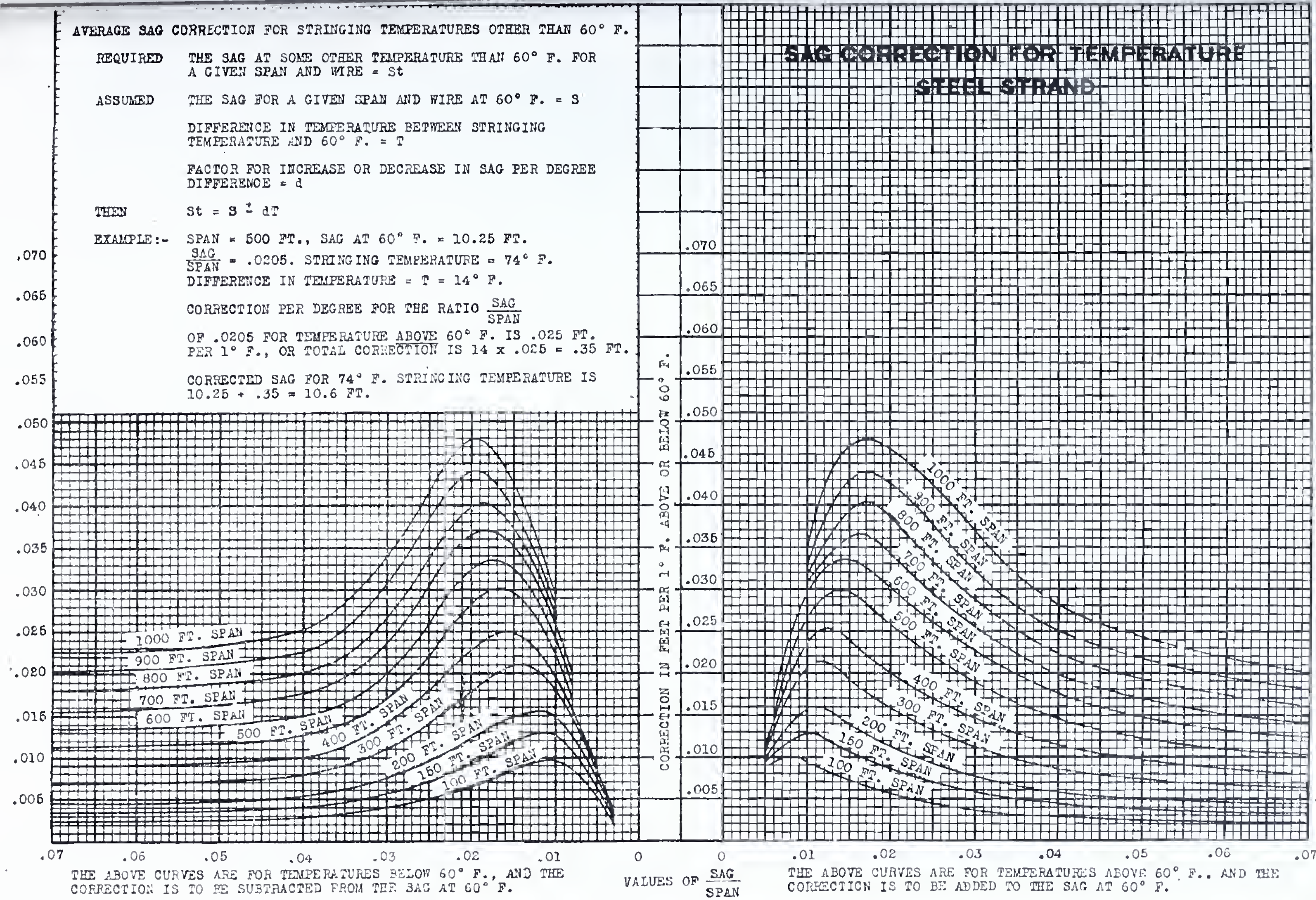
EXAMPLE:- SPAN = 200 FT., SAG AT 60° F. = 2.3 FT. $\frac{\text{SAG}}{\text{SPAN}} = .0115$, STRINGING TEMPERATURE = 40° F. DIFFERENCE IN TEMPERATURE = T = 20° F. CORRECTION PER DEGREE FOR THE RATIO SAG ÷ SPAN FOR TEMPERATURES BELOW 60° F. IS .028 FT. PER 1° F., OR TOTAL CORRECTED SAG FOR 40° F. STRINGING TEMPERATURE IS 2.3 - .028 x 20 = 1.74 FT.

THE ABOVE CURVES ARE FOR TEMPERATURES BELOW 60° F., AND THE CORRECTION IS TO BE SUBTRACTED FROM THE SAG AT 60° F.

THE ABOVE CURVES ARE FOR TEMPERATURES ABOVE 60° F., AND THE CORRECTION IS TO BE ADDED TO THE SAG AT 60° F.

APPENDIX C—Page 29.

Sag Correction for Temperature—Steel Strand.



AVERAGE SAG CORRECTION FOR STRINGING TEMPERATURES OTHER THAN 60° F.

REQUIRED THE SAG AT SOME OTHER TEMPERATURE THAN 60° F. FOR A GIVEN SPAN AND WIRE = St

ASSUMED THE SAG FOR A GIVEN SPAN AND WIRE AT 60° F. = S

DIFFERENCE IN TEMPERATURE BETWEEN STRINGING TEMPERATURE AND 60° F. = T

FACTOR FOR INCREASE OR DECREASE IN SAG PER DEGREE DIFFERENCE = d

THEN $St = S \pm dT$

EXAMPLE:- SPAN = 500 FT., SAG AT 60° F. = 10.25 FT.
$\frac{SAG}{SPAN} = .0205$. STRINGING TEMPERATURE = 74° F.
DIFFERENCE IN TEMPERATURE = T = 14° F.

CORRECTION PER DEGREE FOR THE RATIO $\frac{SAG}{SPAN}$ OF .0205 FOR TEMPERATURE ABOVE 60° F. IS .025 FT. PER 1° F., OR TOTAL CORRECTION IS 14 x .025 = .35 FT.

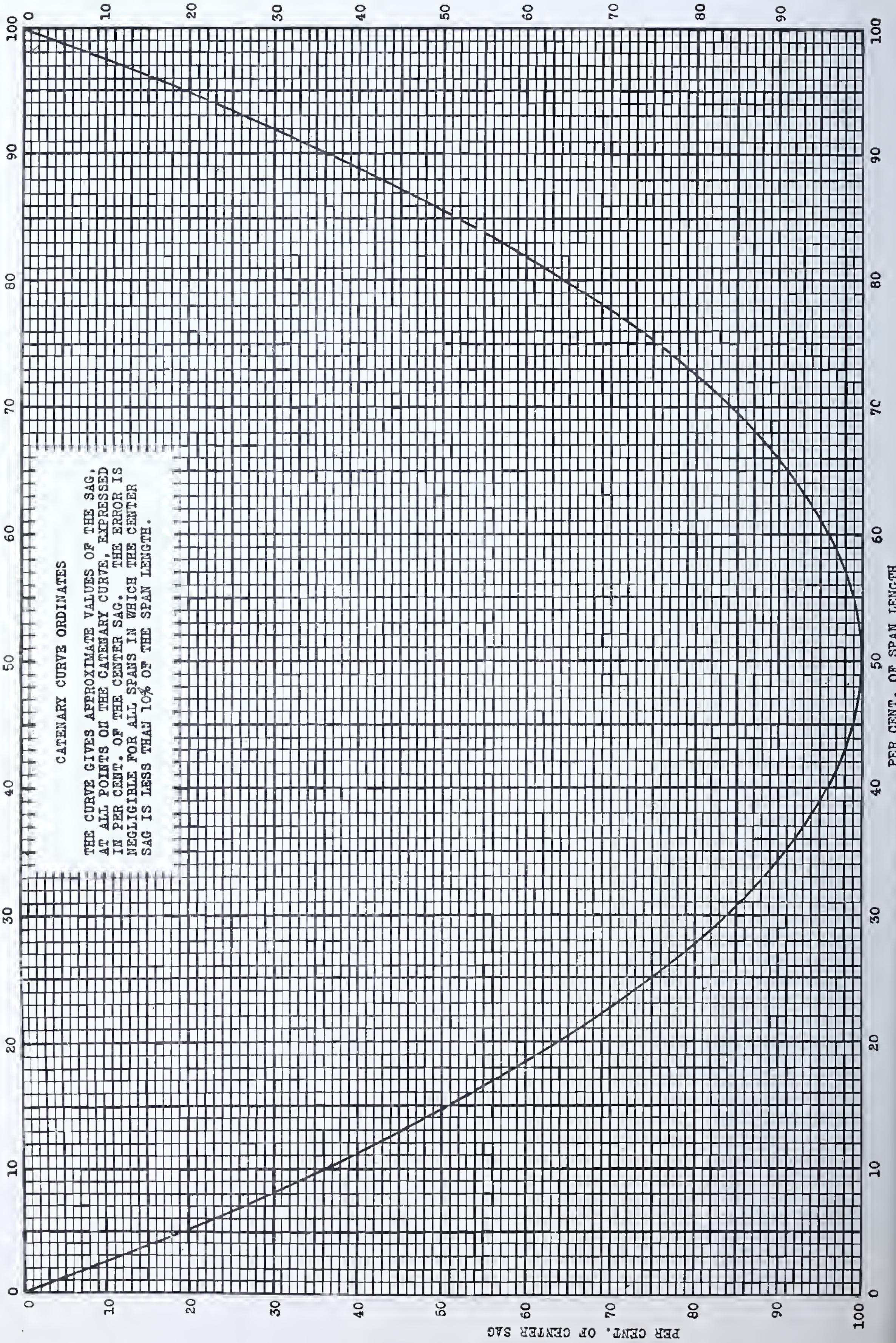
CORRECTED SAG FOR 74° F. STRINGING TEMPERATURE IS 10.25 + .35 = 10.6 FT.

THE ABOVE CURVES ARE FOR TEMPERATURES BELOW 60° F., AND THE CORRECTION IS TO BE SUBTRACTED FROM THE SAG AT 60° F.

THE ABOVE CURVES ARE FOR TEMPERATURES ABOVE 60° F., AND THE CORRECTION IS TO BE ADDED TO THE SAG AT 60° F.

APPENDIX C—Page 30.

Catenary Curve Ordinates.



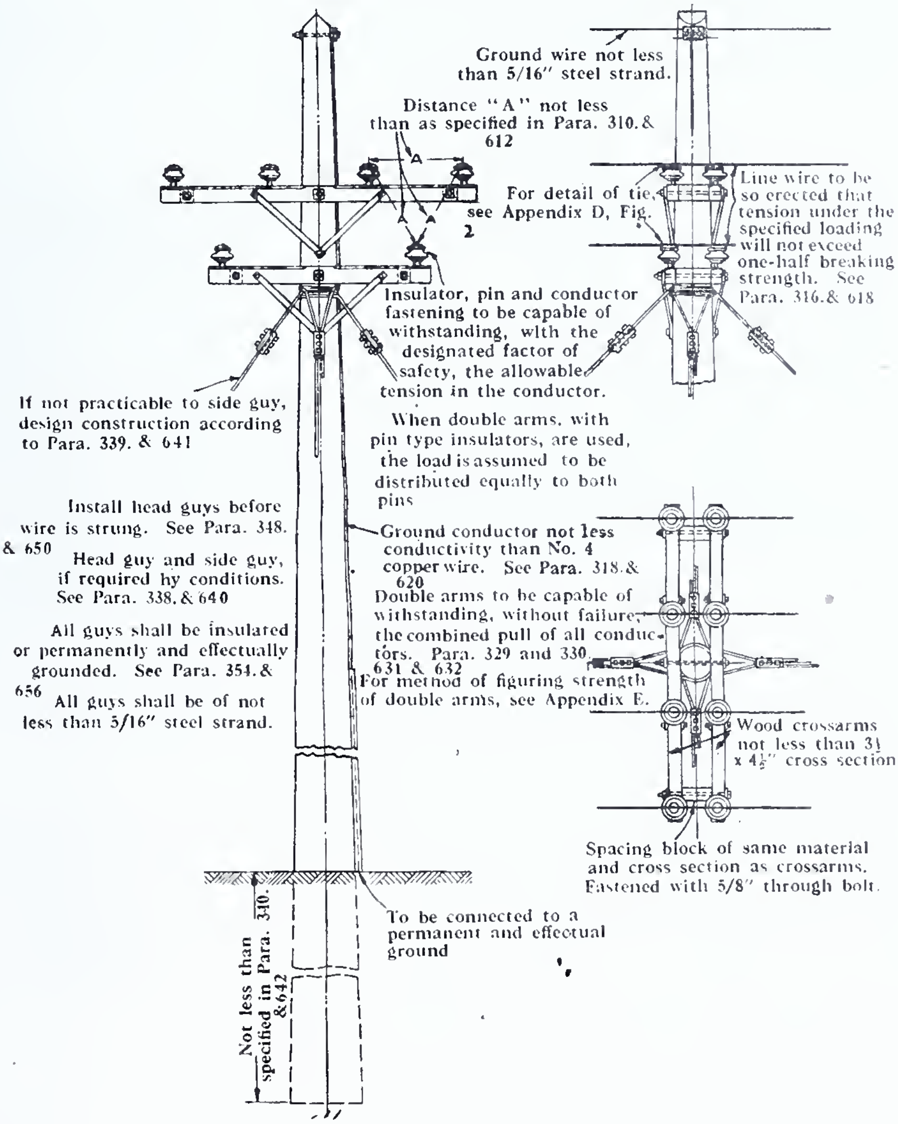
CATENARY CURVE ORDINATES

THE CURVE GIVES APPROXIMATE VALUES OF THE SAG, AT ALL POINTS ON THE CATENARY CURVE, EXPRESSED IN PER CENT. OF THE CENTER SAG. THE ERROR IS NEGLIGIBLE FOR ALL SPANS IN WHICH THE CENTER SAG IS LESS THAN 10% OF THE SPAN LENGTH.

APPENDIX D.

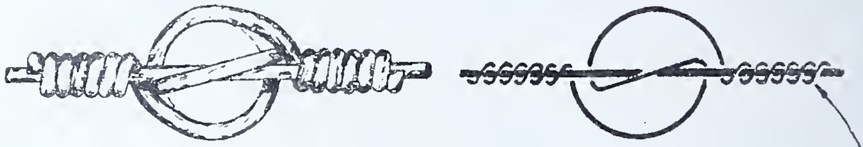
Section III, Paragraphs 326 and 327.
Section VI, Paragraphs 628 and 629.
Section VII, Paragraph 712.

Fig. 1.—Suggested Method of Construction at Crossing Pole, Showing Conductor Attachments with Double Cross-arms, Pin Type Insulators and Ties.

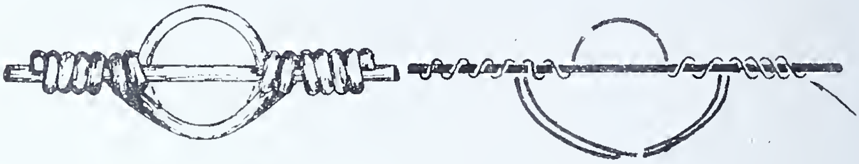

Ground wire not less than 5/16″ steel strand.
Distance "A" not less than as specified in Para. 310.& 612
A
A
A
For detail of tie, see Appendix D, Fig. 2
Line wire to be so erected that tension under the specified loading will not exceed one-half breaking strength. See Para. 316.& 618
Insulator, pin and conductor fastening to be capable of withstanding, with the designated factor of safety, the allowable tension in the conductor.
If not practicable to side guy, design construction according to Para. 339. & 641
When double arms, with pin type insulators, are used, the load is assumed to be distributed equally to both pins
Install head guys before wire is strung. See Para. 348. & 650
Head guy and side guy, if required by conditions. See Para. 338. & 640
Ground conductor not less conductivity than No. 4 copper wire. See Para. 318.& 620
Double arms to be capable of withstanding, without failure, the combined pull of all conductors. Para. 329 and 330, 631 & 632
For method of figuring strength of double arms, see Appendix E.
All guys shall be insulated or permanently and effectually grounded. See Para. 354.& 656
All guys shall be of not less than 5/16″ steel strand.
Wood crossarms not less than 3¼ x 4½″ cross section
Spacing block of same material and cross section as crossarms. Fastened with 5/8″ through bolt.
To be connected to a permanent and effectual ground
Not less than specified in Para. 340. & 642

APPENDIX D—Fig. 2.

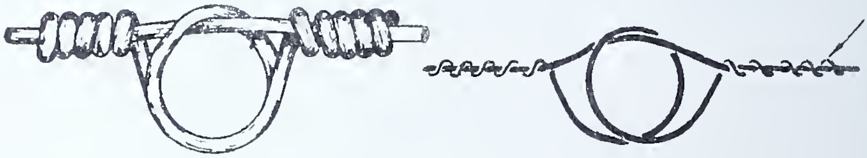
Form of Ties for Power Lines.



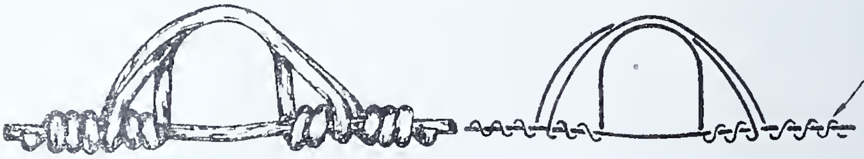
TOP GROOVE TIE NO. 1



TOP GROOVE TIE NO. 2



SIDE GROOVE TIE NO. 3



SIDE GROOVE TIE NO. 4

All tie wires shall have a surface of the same metal as that of the line wire in order to prevent corrosion.

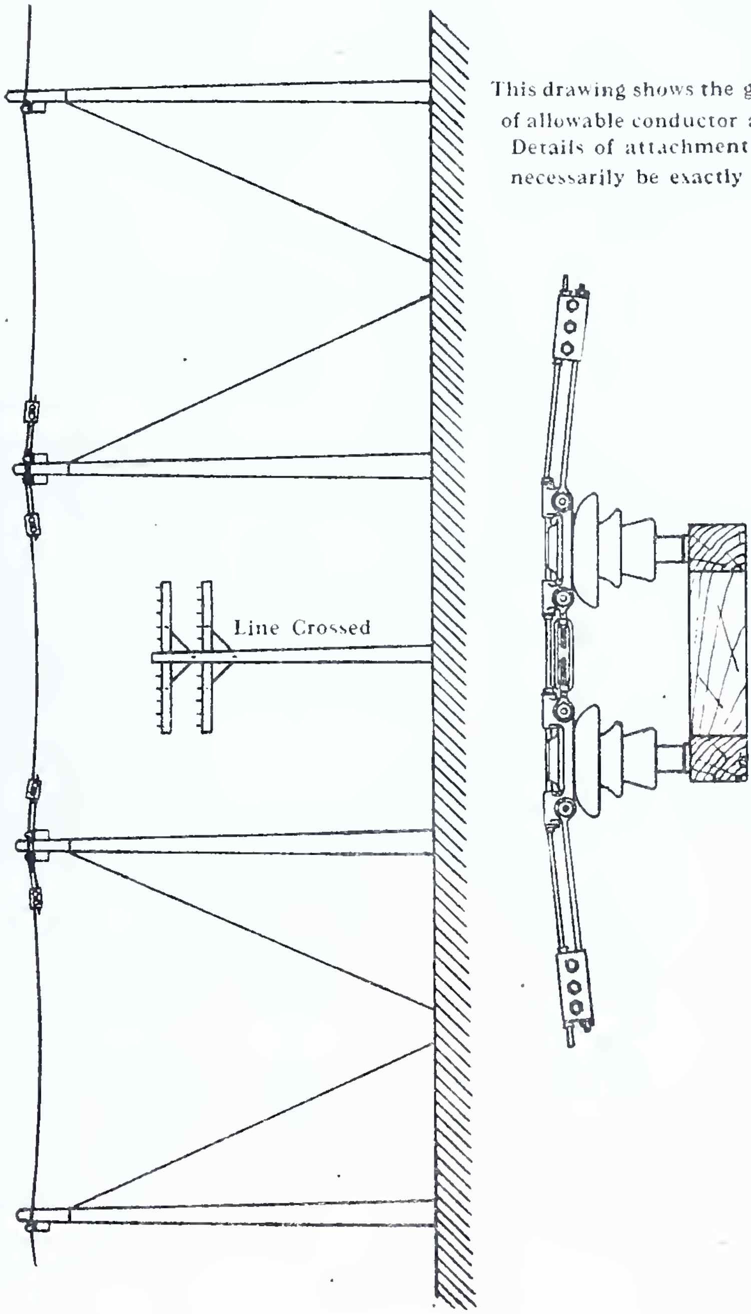
They shall be dead soft so that when twisted up they will hold tight and not tend to spring loose. No tie wire shall ever be replaced on a line after having been removed therefrom.

Use Following Size Wire for Making Ties

# 6	A. W. G.	For	# 6	A. W. G.	Line	Wire
# 6	"	"	# 4	"	"	"
# 4	"	"	# 2	"	"	"
# 4	"	"	# 1	"	"	"
# 4	"	"	# 0	"	"	"
# 2	"	"	# 00	"	and Larger	

APPENDIX D—Fig 3.

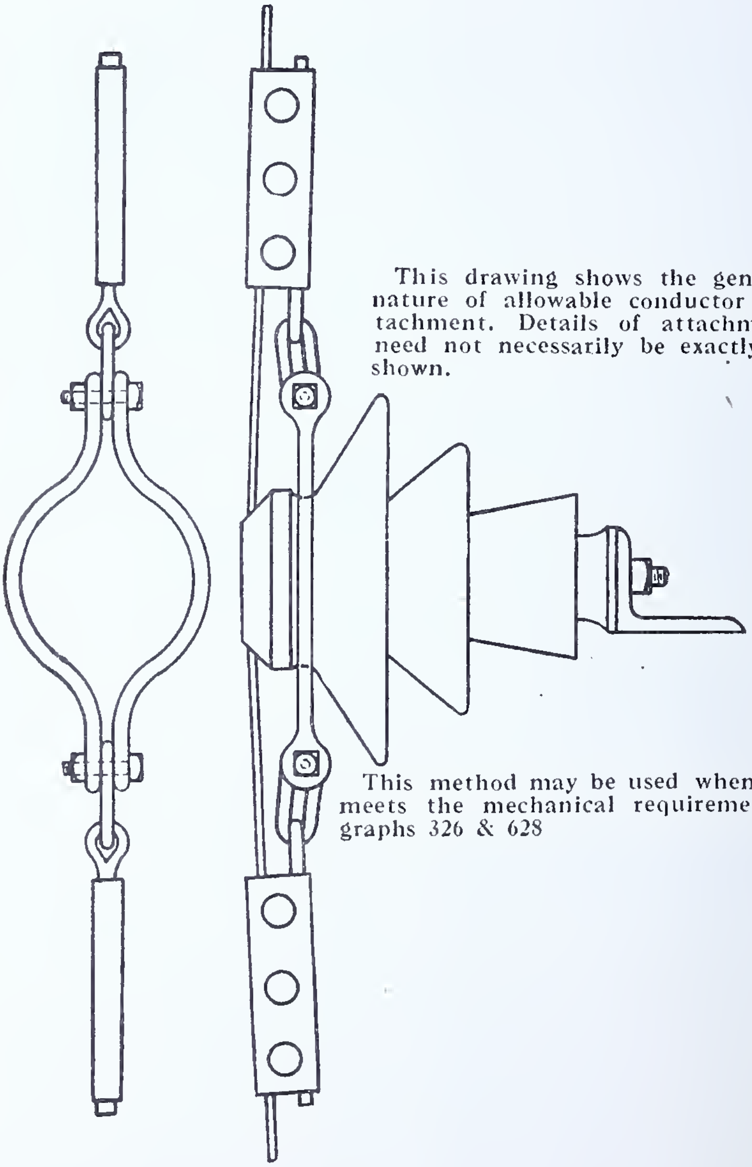
Use of Clamps with Double Pin Type Insulator.



This drawing shows the general nature of allowable conductor attachment. Details of attachment need not necessarily be exactly as shown.

APPENDIX D—Fig. 4.

Use of Clamp with Single Pin Type Insulator and Metal Crossarm.



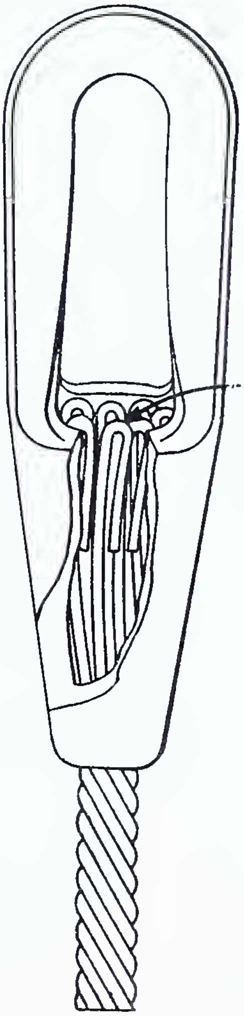
This drawing shows the general nature of allowable conductor attachment. Details of attachment need not necessarily be exactly as shown.

This method may be used when a single pin meets the mechanical requirements of Paragraphs 326 & 628

APPENDIX D—Fig. 5.

Rope Socket for Attaching Large Size Conductor to Dead End Insulator.

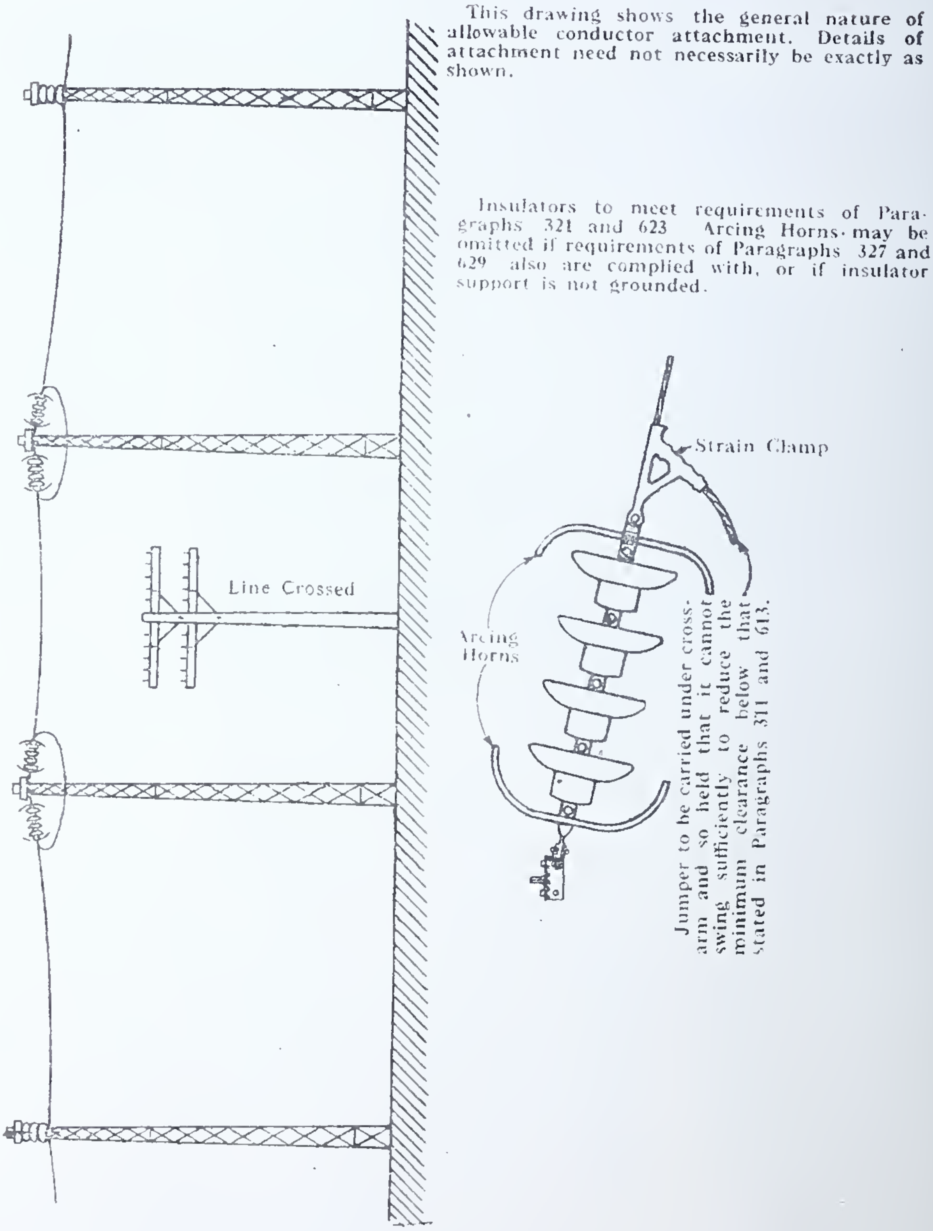
This drawing shows the general nature of allowable conductor attachment. Details of attachment need not necessarily be exactly as shown.



Flare out ends of cable and turn strands back on themselves towards centre of cable and fill with lead or solder.

APPENDIX D—Fig. 6.

Disc Type Insulators. Dead End Construction.



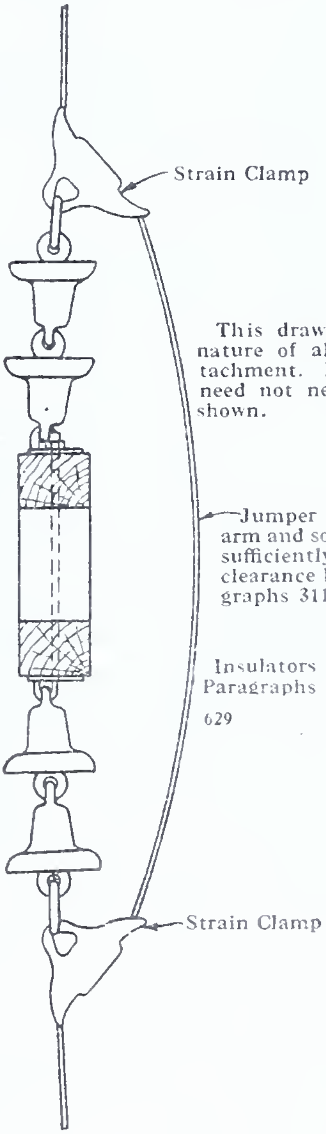
This drawing shows the general nature of allowable conductor attachment. Details of attachment need not necessarily be exactly as shown.

Insulators to meet requirements of Paragraphs 321 and 623. Arcing Horns may be omitted if requirements of Paragraphs 327 and 629 also are complied with, or if insulator support is not grounded.

Jumper to be carried under cross-arm and so held that it cannot swing sufficiently to reduce the minimum clearance below that stated in Paragraphs 311 and 613.

APPENDIX D—Fig. 7.

Use of Disc Type Insulators. Dead End Construction on Wood Crossarms.



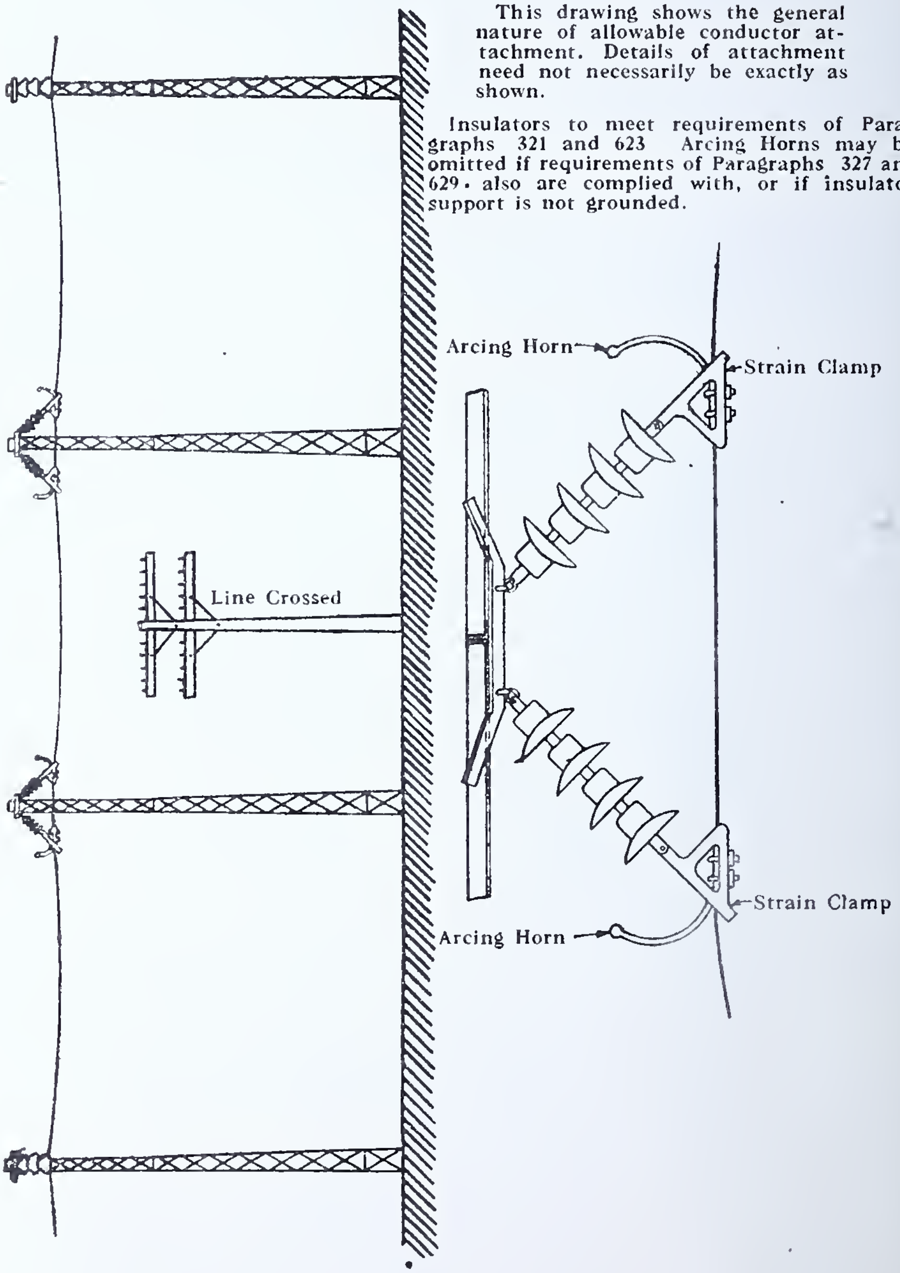
This drawing shows the general nature of allowable conductor attachment. Details of attachment need not necessarily be exactly as shown.

Jumper to be carried under crossarm and so held that it cannot swing sufficiently to reduce the minimum clearance below that stated in Paragraphs 311 and 613.

Insulators to meet requirements of Paragraphs 321 and 623, and 327 and 629

APPENDIX D—Fig. 8.

Disc Type Insulators. Double String.

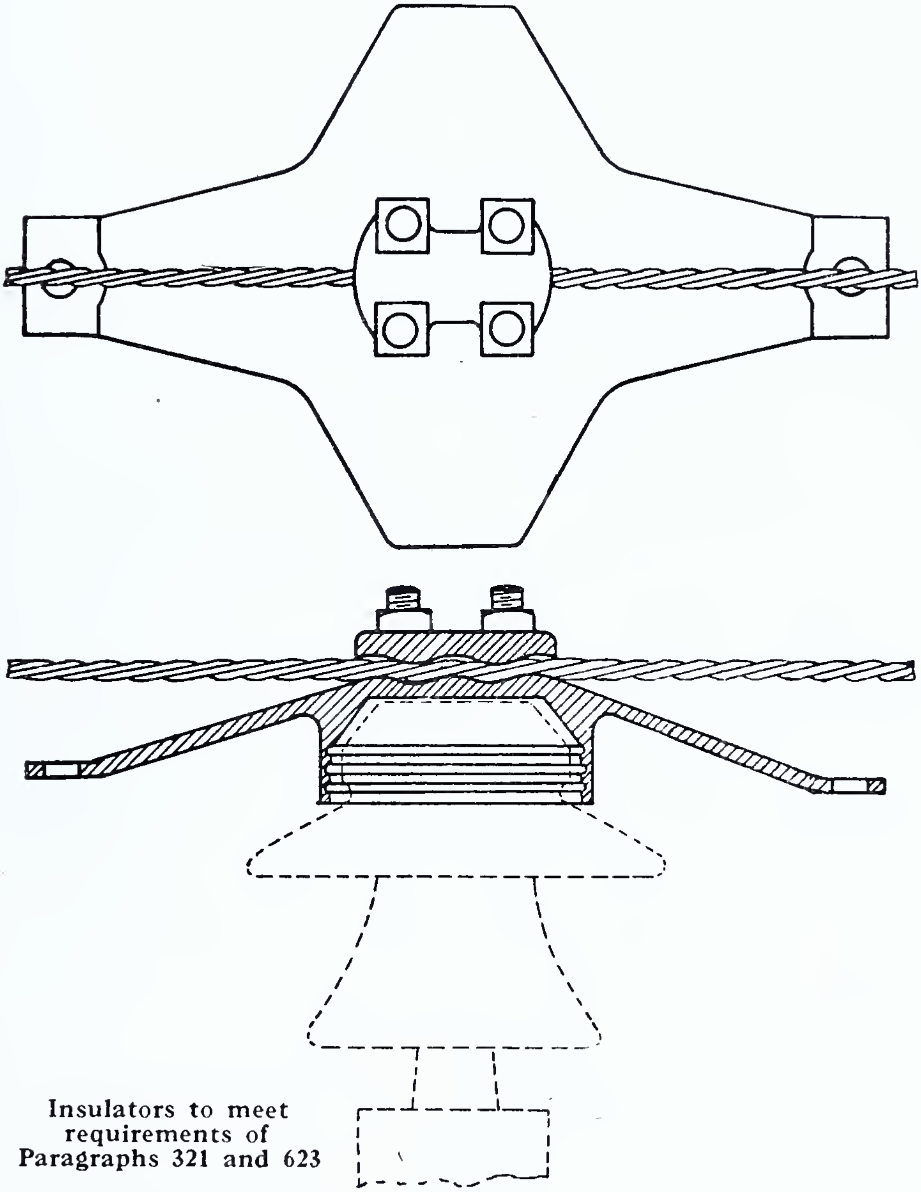


This drawing shows the general nature of allowable conductor attachment. Details of attachment need not necessarily be exactly as shown.

Insulators to meet requirements of Paragraphs 321 and 623 Arcing Horns may be omitted if requirements of Paragraphs 327 and 629 also are complied with, or if insulator support is not grounded.

APPENDIX D—Fig. 9.

Arcing Shield on Pin Type Insulator.



Insulators to meet requirements of Paragraphs 321 and 623

This drawing shows the general nature of allowable conductor attachment. Details of attachment need not necessarily be exactly as shown.

APPENDIX E.

METHOD OF FIGURING STRENGTH OF DOUBLE CROSSARMS.

When double crossarms are connected together at the ends with spacing blocks, bolts or plates, their combined strength in the direction of the pull of the conductors is in excess of double the strength of a single crossarm and is less than the strength of two crossarms of similar dimensions and spacing, connected as a rigid truss.

Allowance is made for this in the following manner:

(a) Double wood or steel crossarms, attached to poles, connected together at the ends by bolts with spacing nuts and washers or by bolts with pipe spacers or similar construction, will be considered as having a strength not in excess of thirty (30) per cent. of the strength of two crossarms, of similar dimensions and spacing, connected as a rigid truss.

(b) Double wood or steel crossarms, attached to poles, connected together at the ends by spacing blocks or plates, bolted or riveted to the crossarms will be considered as having a strength not in excess of forty (40) per cent. of the strength of two crossarms, of similar dimensions and spacing, connected as a rigid truss.

(c) Steel crossarms designed to take shear between the main members will be allowed a factor of strength in accordance with their construction.

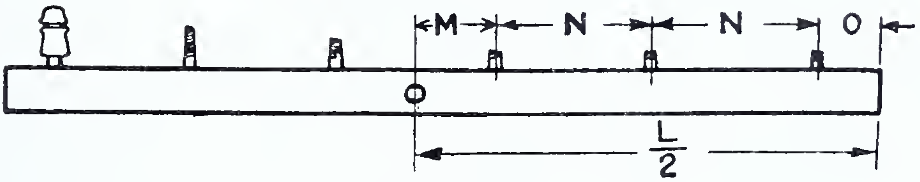
PROBLEM.

Using double standard three and one-half (3½) inch x four and one-half (4½) inch 6-pin cross-arms spaced six (6) inches apart, the separation being maintained by spreader blocks and bolts, will the requirements of Paragraphs 330 (b) and 632 (b) be obtained in arms of Yellow Pine or Washington Fir, if each of the conductors is stressed in the same direction with an unbalanced pull of 2,000 pounds?

APPENDIX E—Page 2.

SOLUTION.

N. E. L. A. STANDARD 6-PIN CROSSARM.



$m = 15$ in.
$n = 14.5$ in.
$o = 4$ in.
$\frac{L}{2} = 48$ in.

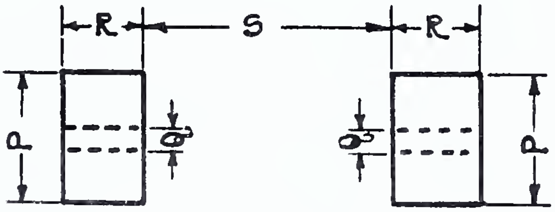
Pull—2,000 pounds on each pin.

In determining the total bending moment, it is necessary to consider the total load applied to one side only.

The total bending moment is the sum of

$2{,}000 \times m = 2{,}000 \times 15 = 30{,}000$ pound-inches.
$2{,}000 \times m+n = 2{,}000 \times 29.5 = 59{,}000$ pound-inches.
$2{,}000 \times m+n+n = 2{,}000 \times 44 = 88{,}000$ pound-inches.
That is, Total Bending Moment, . . . $=177{,}000$ pound-inches.

SECTION OF DOUBLE CROSSARMS.



For N. E. L. A. standard 6-pin crossarms,
$p = 4\frac{1}{2}$ in.
q (diam. of bolt hole) $= 11/16$ in.
$r = 3\frac{1}{2}$ in.
s (spacing between arms) $= 6$ in.

APPENDIX E—Page 3.

$$\text{Moment of Inertia} = \frac{bd^3}{12}$$

$b = p - q = 3\ 13/16$ in. $= 3.81$ in.

$d^3 = (r+r+s)^3 - s^3 = (13^3 - 6^3) = 1981.$

$$\frac{bd^3}{12} = \frac{3.81 \times 1981}{12} = 628.97 = \text{Moment of Inertia}$$

Section Modulus of rigid truss =

$$\frac{\text{Moment of Inertia}}{\frac{1}{2}(r+r+s)} = \frac{628.97}{6.5} = 96.76$$

Allowable Section Modulus (See (b) above) = 40 per cent. of Section Modulus of rigid truss.

$96.76 \times .4 = 38.704.$

Fibre Stress =

$$\frac{\text{Bending Moment}}{\text{Section Modulus}} = \frac{177{,}000}{38.704} = 4573 \text{ lbs. per sq. in.}$$

which is well within the ultimate fibre stress of either Yellow Pine or Washington Fir (as obtained by multiplying the Allowable Working Unit Stress, Appendix F, by the Factor of Safety, Paragraph 359 or 661).

APPENDIX F.

ALLOWABLE WORKING UNIT STRESSES.

Obtained by dividing approved ultimate unit strengths by the factors of safety given in Paragraphs 359 and 661.

Structural Steel:

	Pounds Per Square Inch
Tension (net section),	18,000
Shear,	14,000
Compression,	$18{,}000 - 60\frac{L}{R}$

NOTE:—The following allowable working unit stresses for structural steel may be used in figuring steel towers to meet the requirements of Paragraph 338—(b) Section III, or Paragraph 640—(b) Section VI.

Tension (net section)	24,000
Shear	18,700
Compression	$24{,}000 - 60\frac{L}{R}$

Bolts, Rivets, Pins:

Shear,	12,000
Bearing,	24,000
Bending,	18,000

Conductor:

Copper, hard-drawn, solid—		
A. W. G.	4/0, 3/0, 2/0,	25,000
A. W. G.	1/0,	27,500
A. W. G.	No. 1,	28,500
A. W. G.	No. 2, 4, 6,	30,000
Copper, soft-drawn, solid,		17,000
" hard-drawn, stranded,		30,000
" soft-drawn, stranded,		17,000
Aluminum, hard-drawn, stranded,		11,500

APPENDIX F—Page 2.

Timber:	**Working Values for Bending Lbs. per Sq. In.**
Eastern White Cedar,	900
Chestnut,	1,275
Washington Cedar,	1,275
Idaho Cedar,	1,275
Port Orford Cedar,	1,725
Long Leaf Yellow Pine,	1,500
Short Leaf Yellow Pine,	1,200
Douglas Fir,	1,350
White Oak,	1,425
Red Cedar,	1,050
Bald Cypress (Heartwood),	1,200
Redwood,	975
Catalpa,	750
Juniper,	825

Values based upon factor of safety of four (4); compression working values equal bending working values multiplied by $\left(1-\frac{L}{60D}\right)$;

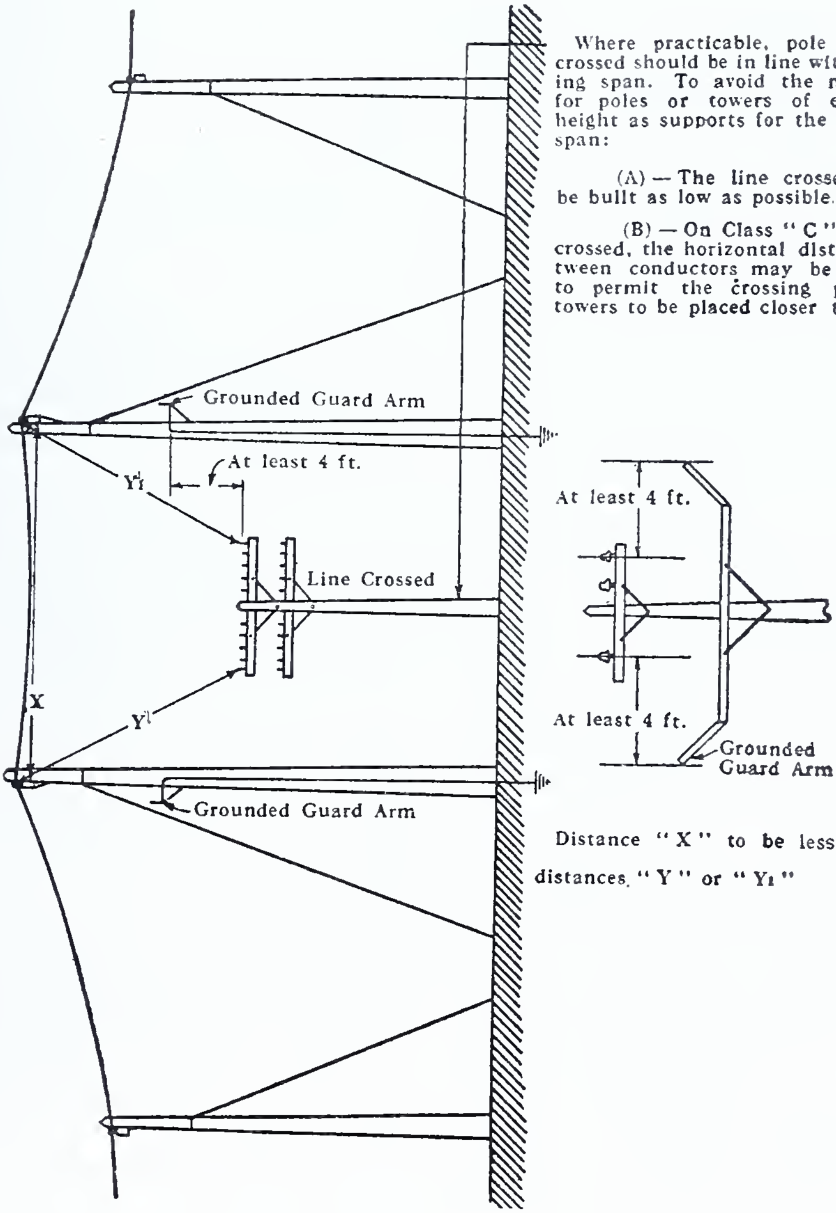
L—Length in inches.

D—Length side, or diameter, in inches.

APPENDIX G.

Section III, Paragraph 362.
Section VI, Paragraph 664.

Fig. 1.—Short Span Construction.



Where practicable, pole of line crossed should be in line with crossing span. To avoid the necessity for poles or towers of excessive height as supports for the crossing span:

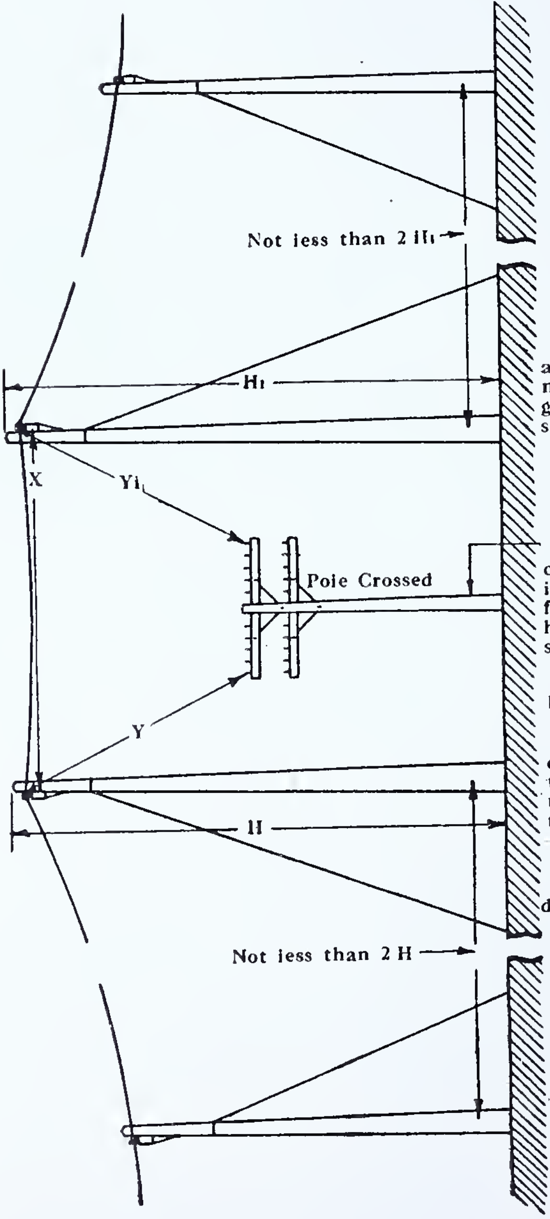
(A) — The line crossed shall be built as low as possible.

(B) — On Class "C" lines so crossed, the horizontal distance between conductors may be reduced to permit the crossing poles or towers to be placed closer together

Distance "X" to be less than distances "Y" or "Y_1"

APPENDIX G—Fig. 2.

Short Span Construction.



Conductors in the crossing span and the next adjoining spans shall meet the requirements of Paragraphs 313-317 and 615-619 inclusive.

Where practicable, pole of line crossed should be in line with crossing span. To avoid the necessity for poles or towers of excessive height as supports for the crossing span:

(A) — The line crossed shall be built as low as possible.

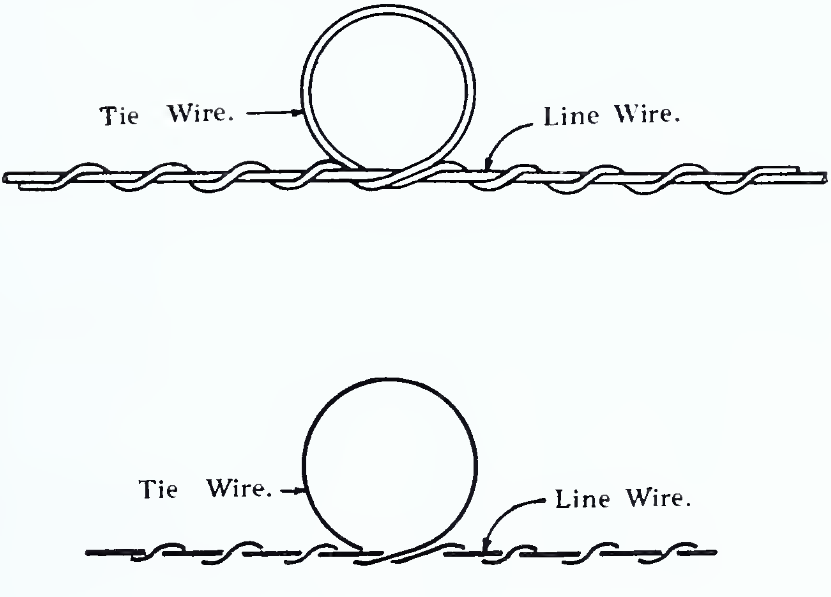
(B) — On Class " C " lines so crossed, the horizontal distance between conductors may be reduced to permit the crossing poles or towers to be placed closer together.

Distance " X " to be less than distances " Y " or " Y_1 "

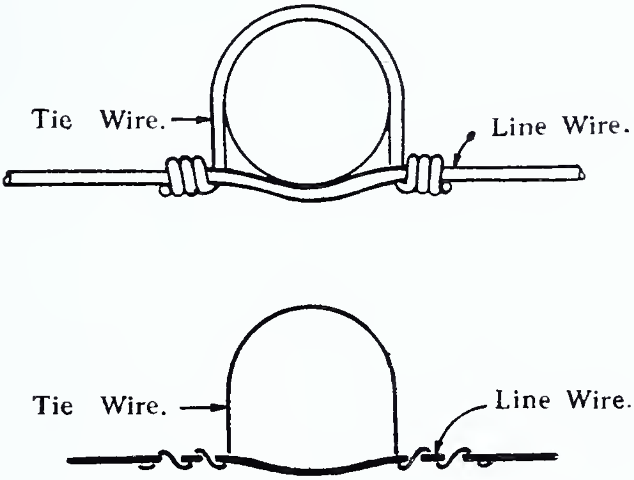
APPENDIX H.

Section V, Paragraph 542.

Method of Tying Wire to Insulators.



Tie For Copper Wire.



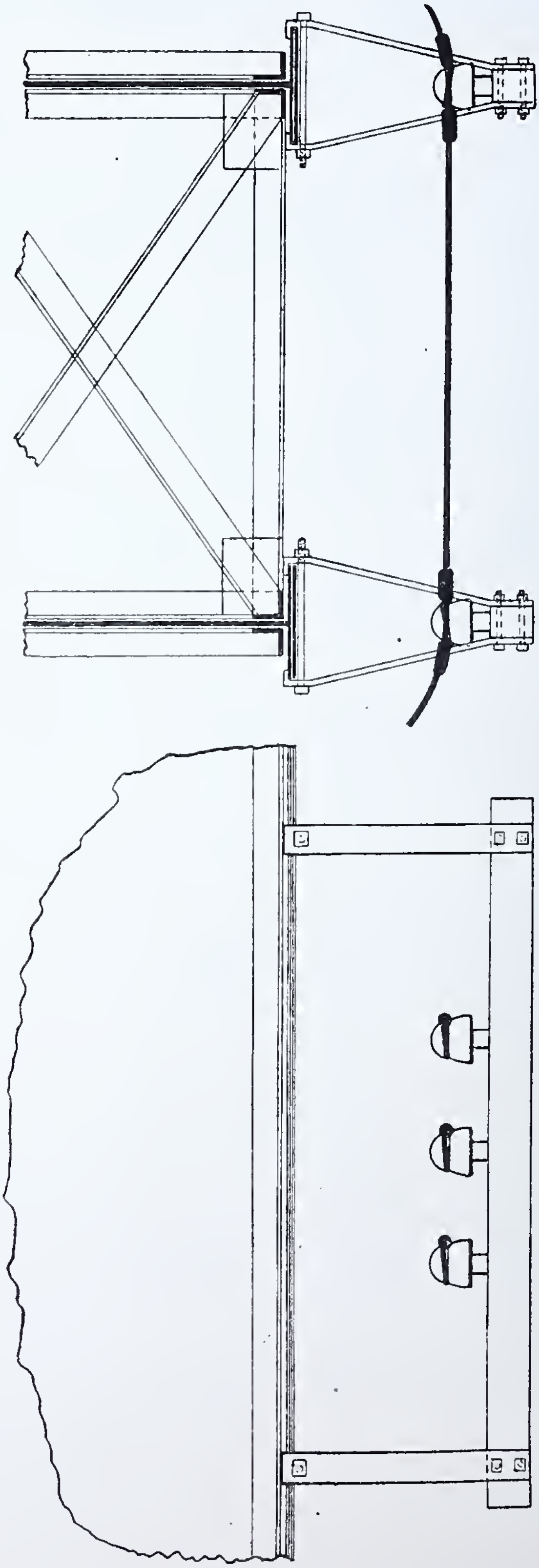
Tie For Iron Wire.

For size of tie wires see Paragraph 542.

APPENDIX I.

Section VII, Paragraph 714.

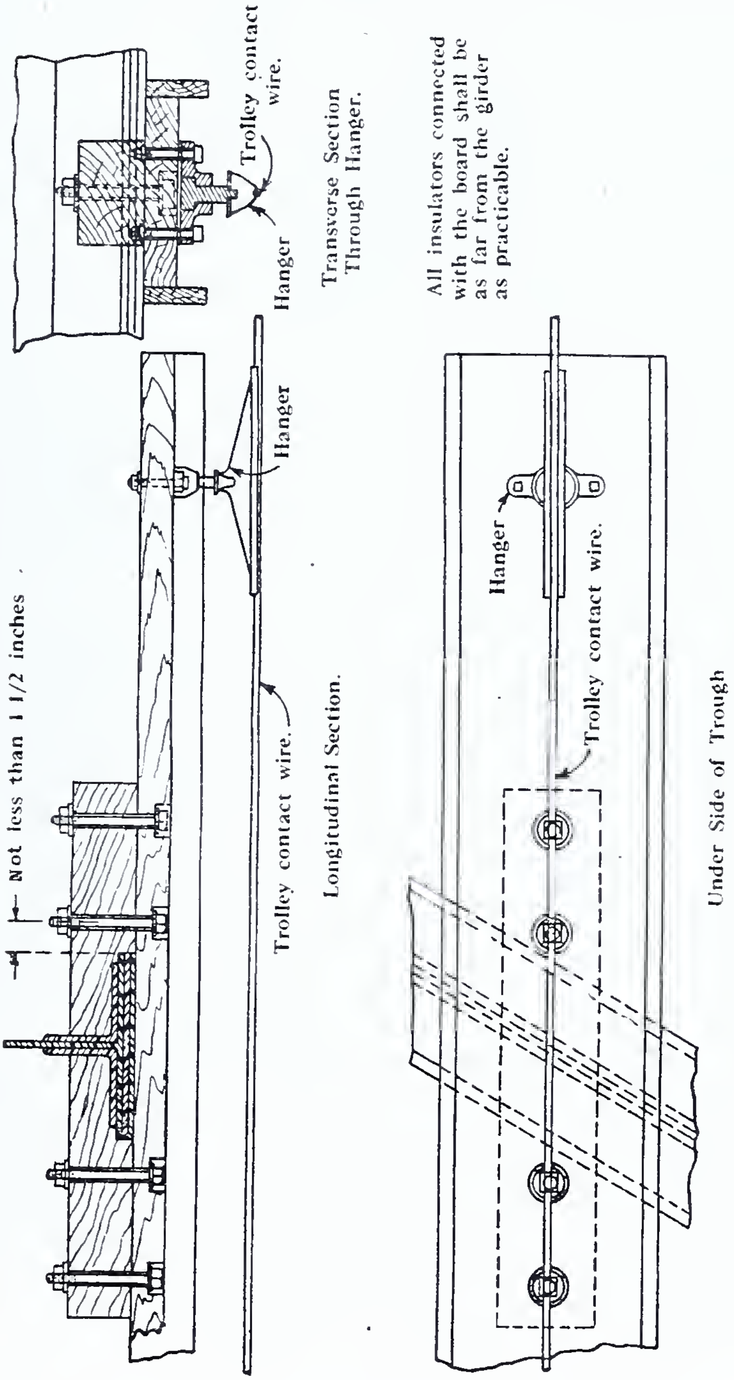
Fig. 1.—Suggested Method of Attaching Conductor in open Construction Steel Bridges.



APPENDIX I—Fig. 2.

Section VII, Paragraph 716.

Suggested Design of Wooden Inverted Trough for Protection where Trolley Contact Wires are Attached to Steel Bridges.



Transverse Section Through Hanger.

Longitudinal Section.

Under Side of Trough

All insulators connected with the board shall be as far from the girder as practicable.

APPENDIX J.

TYPICAL CROSSING OF POWER LINE OVER RAILROAD.

WITH WOODEN POLE CONSTRUCTION IN WHICH CROSSING POLES CANNOT BE SIDE GUYED.

DATA OF CROSSING.

Voltage of Circuit.—22,000 Volts.

Lightning Protection Wire.—One (1) five-sixteenths (5/16) inch Galvanized Steel Strand, ultimate strength 4,860 pounds.

Conductors.—Twelve (12) No. 2 A. W. Gauge Soft Drawn Copper—Solid—Bare.

Insulators.—Porcelain, to meet requirements of Paragraphs 623 and 629.

Pins.—Steel, with five-eighths (5/8) inch bolt.

Ties.—No. 4 A. W. Gauge—Top Groove No. 1 or No. 2—Appendix D, Figure 2.

Crossarms.—Three and one-half (3½) inches by four and one-half (4½) inches Yellow Pine—eleven-sixteenths (11/16) inch pin holes—eleven-sixteenths (11/16) inch hole for through pole bolt.

Poles.—Chestnut—Class "A."

Pole Framing.—Lightning protection wire attached six (6) inches from top of pole. Center of top crossarm five (5) feet below point of attachment of lightning protection wire. Center of second crossarm two and one-half (2½) feet below center of top crossarm. Center of third crossarm two and one-half (2½) feet below center of second crossarm.

Location of Poles.—The location of poles in reference to railroad tracks, and in reference to the associated paralleling pole line of the railroad, is as shown in the plan given on Page 153.

Railroad Pole Line.—Height of top wire on the associated paralleling pole line of the railroad company, above elevation of top of rail at point of crossing, twenty-four (24) feet.

APPENDIX J—Page 2.

Length of Crossing Span.—150 Feet.
Length of Adjacent Span.—120 Feet.

Level of ground at base of pole assumed to be at same elevation as top of rail.

CONSTRUCTION REQUIREMENTS DETERMINED AS FOLLOWS:

Sag of Conductors (Under Normal Conditions).

The sag in the crossing span will be determined from curve for soft drawn, bare, solid copper wire given on Page 92.

For No. 2 A. W. Gauge, span 150 feet—sag = two and seven-tenths (2.7) feet.

In adjacent spans, for balanced condition of stress, under normal conditions, the sags will be inversely proportional to the square of the length of the spans. In the spans adjacent to the crossing span, the normal sag, therefore, will be

$$2.7 \text{ feet} \times \frac{(120)^2}{(150)^2} = 1.73 \text{ feet}$$

Sag of Lightning Protection Wire.

From sag curves of steel strand given on Page 101, the normal sag for five-sixteenths (5/16) inch Siemens-Martin strand, span 150 feet, is less than six (6) inches. Therefore, the same sag as for the conductors, or two and seven-tenths (2.7) feet in crossing span, and one and seventy-three one-hundredths (1.73) feet in adjacent spans, can be used with increased factor of safety.

Spacing Conductors—From Page 158.

Volts	Span	Sag	Required Spacing
22,000	100 Feet	2 Feet	2 Feet 6 Inches
22,000	200 Feet	4 Feet	2 Feet 6 Inches

Therefore, for span of 150 feet, sag two and seven-tenths (2.7) feet, the same spacing would be required, or two (2) feet six (6) inches. As the conductors on adjacent crossarms are supported in the same vertical plane, the gain spacing for crossarms will also be two (2) feet, six (6) inches.

APPENDIX J—Page 3.

Clearances of Conductors Over Crossarms.

The vertical clearance of the conductor above the crossarm, obtained from Page 157, for 22,000 volts, is six and seventy-five one-hundredths (6.75) inches. This makes the vertical distance between the conductor and the centre of the crossarm nine (9) inches.

Vertical Clearances of Conductors Over Railroad Pole Lines.

The pole has a height of fifty (50) feet, and is set seven (7) feet in the ground. From the dimensions of the pole framing given in the "Data of Crossing" above, the distance from the centre of the lowest crossarm to the ground will be thirty-two and fifty one-hundredths (32.50) feet. The distance of the conductors above the crossarms is nine (9) inches. Therefore, the conductors on the lowest crossarm are thirty-three and twenty-five one-hundredths (33.25) feet above the ground level. The ground level is given as at the same elevation as the top of the rail.

The sag of the conductors in the crossing span is determined above as two and seven-tenths (2.7) feet. From the plan given on Page 153, the distance "D" referred to on Page 155, is seventy-five (75) feet. Therefore, from this table the minimum vertical clearance required over the top wire of the railroad pole line at the point of crossing is six (6) feet. This point of crossing is, from the plan, fifty-four (54) feet from the nearest crossing pole, "B," or thirty-six (36) per cent. of the crossing span length. The sag at thirty-six (36) per cent. of the span length is, from the curve, Page 116, ninety-two (92) per cent. of the centre sag. The centre sag is two and seven-tenths (2.7) feet making the sag at point of crossing over railroad pole line ninety-two (92) per cent. of two and seven-tenths (2.7) feet, or two and forty-eight one-hundredths (2.48) feet. Therefore, the clearance of lowest conductor over elevation of top of rail at point of crossing with the railroad pole line will be thirty-three and twenty-five one-hundredths (33.25) feet, less two and forty-eight one-hundredths (2.48) feet, or thirty and seventy-seven one-hundredths (30.77) feet. As the top wire of railroad pole line at this point is given as twenty-four (24) feet above top of rail, the clearance at this point between the lowest power wire and the top wire of the railroad pole line will be six and seventy-seven one-hundredths (6.77) feet, which is in excess of the minimum required clearance of six (6) feet determined above.

Clearance of Lowest Power Line Over Railroad Track.

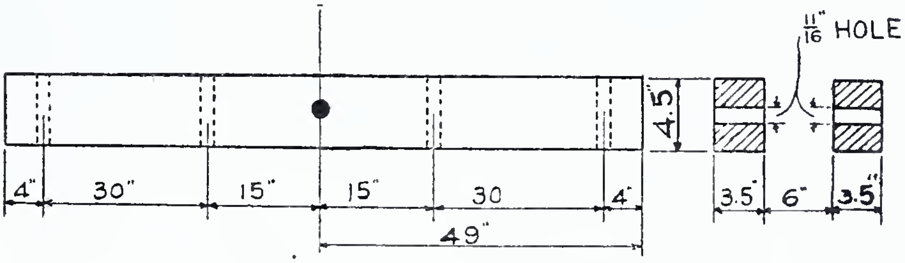
The centre sag of the crossing span, determined as above, is two and seven-tenths (2.7) feet. Therefore, the clearance over the top of the rails will be the height of the lowest conductor above the top of the rail at its point of attachment on the pole, less this sag, or thirty-three and twenty-five one-hundredths (33.25) feet, less two and seven-tenths (2.7) feet, equal to thirty and fifty-five one-hundredths (30.55) feet, which is greater than the vertical clearance required at this point from Page 156, the minimum required clearance being twenty-eight (28) feet, six (6) inches.

Conductor Attachments.

As the conductors in the crossing span are strung with a normal sag of two and seven-tenths (2.7) feet, the stress in each conductor, under the conditions of maximum loading (zero (0) degrees Fahrenheit, one-half ($\frac{1}{2}$) inch ice and eight (8) pounds wind) will be equal to one-half ($\frac{1}{2}$) the ultimate strength of the conductor, or, from Page 160, 890 pounds. As this is less than 2,000 pounds, the conductors may be attached to double pin type insulators, with ties as specified in Paragraphs 326 and 628, and as shown in Appendix D, Figure 1.

Crossarms.

Crossarms to be of Long Leaf Yellow Pine, of dimensions as shown in sketch below, and to be double, with spacing blocks:



Dead Load on Crossarms (Paragraph 632 (a)).

The vertical load on the two (2) crossarms, under maximum conditions of loading, will be, for each conductor, equal to the weight per foot of ice covered wire, times one-half ($\frac{1}{2}$) the sum of the length of the crossing and adjacent span, or .673 lbs (from Page 160) $\times \frac{150 + 120}{2} = 91$ lbs.

The weight per arm per conductor = 45.5 lbs.

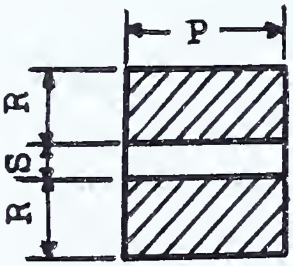
Bending Moment per arm

$$
\begin{aligned}
45.5 \times 15 &= 683 \text{ pound-inches.}\\
45.5 \times 45 &= \underline{2,048} \text{ pound-inches.}
\end{aligned}
$$

Total Bending Moment, 2,731 pound-inches.

The point of maximum bending moment will be at the through bolt attaching the arm to the pole, at which point the cross section of the arm is reduced by the amount of the bolt hole.

The following shows the method of figuring the moment of inertia of one crossarm at this point:



P = 3.5

R = 1.90625

S = .6875

$$\text{Moment of Inertia} = \frac{bd^3}{12}$$

$b = P = 3.5$

$d^3 = (R+R+S)^3 - S^3 = 90.8$

$\frac{bd^3}{12} = 26.5$ Moment of Inertia

$$\text{Section Modulus} = \frac{\text{Moment of Inertia}}{\frac{1}{2}\,(R+R+S)}$$

$$= \frac{26.5}{2.25} = 11.8$$

APPENDIX J—Page 6.

Fibre Stress =

$$\frac{\text{Bending Moment}}{\text{Section Modulus}} = \frac{2731}{11.8} = 231 \text{ lbs.}$$

As the allowable fibre stress, from Appendix F, is 1,500 pounds, the stress due to the dead load is well within the limit.

In the above calculation, no account has been taken of weight of pins and insulators, and of ice on the crossarm, and no allowance made for additional strength afforded by crossarm braces.

Unbalanced or Broken Wire Load on Crossarms (Paragraphs 632 (b).

> "To withstand, at all times without failure, the unbalanced stress due to the combined pull in one direction of all the conductors supported,—the pull of each conductor being taken as the tension in the conductor due to the specified load."

The pull of each conductor due to the specified loading, as the assumed sag, is equal to one-half ($\frac{1}{2}$) the ultimate strength of the conductor, or, from Page 160, for No. 2 A. W. Gauge, soft drawn, bare, solid copper wire, 890 pounds.

The fibre stress for double arms fitted with spacing blocks for the unbalanced load due to the pull of the four (4) conductors supported, will be determined, as set forth in Appendix E, as follows:

Using the notation given in the sketch in that Appendix:

$m = 15$ inches

$n = 30$ inches

$o = 4$ inches

$\frac{L}{2} = 49$ inches

Pull = 890 pounds per conductor.

Bending Moment

$890 \times 15 = 13{,}500$ pound-inches.

$890 \times 45 = 40{,}050$ pound-inches.

Total Bending Moment 53,550 pound-inches.

$p = 4.5$ inches.
q (diam. of bolt hole) $= 11/16$ inch.
$r = 3.5$ inches.
$s = 6.0$ "

$$\text{Moment of Inertia} = \frac{bd^3}{12}$$

$b = p - q = 3\ 13/16$ inches $= 3.81$ inches.
$d^3 = (r + r + s)^3 - s^3 = (13^3 - 6^3) = 1981.$

$$\frac{bd^3}{12} = \frac{3.81 \times 1981}{12} = 628.97 \text{ Moment of Inertia.}$$

Section Modulus of rigid truss $=$

$$\frac{\text{Moment of Inertia}}{\frac{1}{2}(r + r + s)} = \frac{628.97}{6.5} = 96.76.$$

Allowable Section Modulus $=$ 40% of Section Modulus of rigid truss $= 96.76 \times .4 = 38.704.$

Fibre Stress $=$

$$\frac{\text{Bending Moment } 53{,}550}{\text{Section Modulus } 38.704} = 1{,}383 \text{ lbs.}$$

Under the unbalanced stress due to the combined pull in one direction of all conductors supported, the double arms can be stressed to their ultimate strength. This ultimate strength is, for Long Leaf Yellow Pine, 6,000 pounds, and the calculated fibre stress is well within this limit.

Poles.

The crossing poles are given as Class "A" Chestnut. Dimensions are as follows:

Length	50	feet
Height above ground	43	feet
Circumference at top	24	inches
Diameter at top	7.63	inches
Circumference 6 feet from butt	51	inches
Circumference at ground	50.4	inches
Diameter at ground	16	inches

APPENDIX J—Page 8.

Distance from ground line to conductors supported is given as follows:

Lightning protection wire	42.50 feet
Conductors on top arm	38.25 feet
" " second arm	35.75 feet
" " lowest arm	33.25 feet

Ground level at base of pole is stated to be at the same elevation as top of rail.

Transverse Load on Poles "B" and "C."

Due to wind on ice covered poles and wires. Assume maximum stress to be at the ground line.

The approximate moment at the ground, due to wind pressure on the pole would be

$$M_p = \frac{PH^2 (D_1 + 2D_2)}{72} \text{ pound-feet.}$$

P = Pressure in pounds per square foot on projected area of ice covered pole.
H = Height of pole above ground, in feet.
D_1 = Diameter of pole at ground, in inches.
D_2 = Diameter of pole at top, in inches.

The moment at the ground, due to wind pressure on the wires, would be

$$M_c = L\ n\ P_h \frac{(S_1 + S_2)}{2} \text{ pound-feet.}$$

P_h = Horizontal load per lineal foot for 8.0 pounds wind and ½ inch ice. Values for P_h for various sizes of wire are given on Pages 160 to 165, inclusive.

L = Height of wires above ground, in feet.
n = Number of wires.
S_1 and S_2 = Length of adjacent spans, in feet.
M_p = Moment due to wind pressure on pole.
M_{co} = Moment due to wind pressure on lightning protection wire.
M_{c1} = Moment due to wind pressure on wires on top arm.
M_{c2} = Moment due to wind pressure on wires on second arm.

APPENDIX J—Page 9.

M_{c3} = Moment due to wind pressure on wires on third arm.

Total Moment = $M_p + M_{co} + M_{c1} + M_{c2} + M_{c3}$.

Moment due to wind pressure on pole with ½ inch ice covered surface.

$$D_1 + \tfrac{1}{2} \text{ inch ice} = 17.00$$

$$D_2 + \tfrac{1}{2} \text{ inch ice} = 8.63$$

$$M_p = \frac{8\ (43)^2 \times (17 + 2\ (8.63)}{72} = 7{,}039 \text{ lb.-ft.}$$

Moment due to lightning protection wire

P_h = .875 for 5/16 inch galvanized strand—Page 161.

$$M_{co} = 42.5 \times 1 \times .875 \times \frac{(120 + 150)}{2} = 5{,}020 \text{ lb.-ft.}$$

Moment due to wires on cross-arms

P_h = .839 for No. 2 A. W. Gauge, solid, bare wire.

$$M_{c1} = 38.25 \times 4 \times .839\ \frac{(120 + 150)}{2} = 17{,}330 \text{ lb.-ft.}$$

$$M_{c2} = 35.75 \times 4 \times .839\ \frac{(120 + 150)}{2} = 16{,}197 \text{ lb.-ft.}$$

$$M_{c3} = 33.25 \times 4 \times .839\ \frac{(120 + 150)}{2} = 15{,}064 \text{ lb.-ft.}$$

Total Bending Moment = 60.650 lb.-ft.

$$\text{Moment of Resistance} = M = \frac{F \pi D_1^3}{384} = \frac{FD_1^3}{122}$$

In which M = Moment in pound-feet.

F = Fibre stress in pounds per square inch.

D_1 = Diameter of pole at ground.

$$F\ \frac{16^3}{122} = 60{,}650 \text{ pounds}$$

$$F = 1{,}807 \text{ `` } = \text{fibre stress per square inch.}$$

The allowable fibre stress for chestnut poles, from Appendix F, is 1,275 pounds. Therefore, to meet the requirements of

Paragraph 640 (a), the Poles "B" and "C" should be side guyed, but it is assumed that it is physically impossible to side guy these poles, and that the nearest poles that can be side guyed are "A" and "E." The guyed poles "A" and "E," and the entire line between them, must, therefore, be built in accordance with the requirements of Paragraph 641. Poles "B," "C" and "D" carry thirteen (13) wires, and must be able to withstand the transverse load of the wind on the ice covered poles and wires, with a factor of safety of two (2). A factor of safety of two (2) will permit a fibre stress of 2,550 pounds.

The figured fibre stress of these poles, due to the transverse load, as calculated above, is 1,807 pounds, and is, therefore, well within the requirements of Paragraph 641.

Unbalanced Load on Crossing Poles "B" and "C."

(Paragraph 640 (b).)

"To withstand, at all times without failure, the unbalanced stress due to the combined pull in the direction of the crossing of all the conductors supported,—the pull of each conductor being taken as the tension in the conductor due to the specified load."

Pull of ground wire, one-half ($\frac{1}{2}$) ultimate strength=2,340 lbs.

Pull of each conductor, one-half ($\frac{1}{2}$) ultimate strength=890 lbs.

Bending Moments

2,430 × 42.50 = 103,275 pound-feet.
3,560 × 38.25 = 136,170 pound-feet.
3,560 × 35.75 = 127,270 pound-feet.
3,560 × 33.25 = 118,370 pound-feet.

Total Moment = 485,085 pound-feet.

$$F \frac{16^3}{122} = 485{,}085.$$

F = 14,450 pounds per square inch.

The allowable fibre stress under this unbalanced load is 5,100 pounds. The calculated fibre stress is in excess of this amount, and, therefore, the crossing poles "B" and "C" must be head guyed.

Side Guys (for Poles "A" and "E").

From Paragraph 641 (a) the poles must be guyed to take the transverse load due to wind and ice on entire line between the guyed poles, this transverse load being figured as taken entirely by the guys (Paragraph 651).

The transverse force acting on the poles will include the wind pressure on the ice covered pole, and the transverse force due to the wind pressure on the ice covered wires. The length of the conductor used in figuring this transverse force on each of the two guyed poles will be equal to one-half (½) the distance between the guyed poles, plus one-half (½) the length of the span adjacent to the pole, or to

$$\frac{510}{2} + \frac{120}{2} = 315 \text{ feet.}$$

Moment due to wind on pole (from Page 147) M_p 7,039 pound-feet.

Moment due to conductors—

$M_{co} = 42.5 \times 1 \times .875 \times 315 = 11{,}714$ pound-feet.

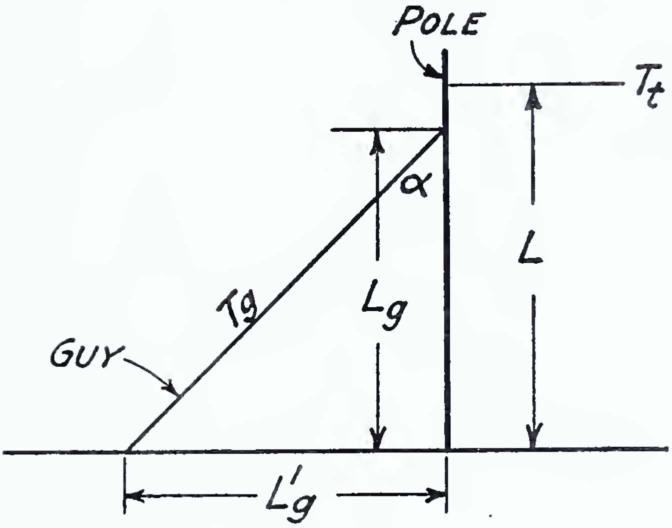
$M_{c1} = 38.25 \times 4 \times .839 \times 315 = 40{,}436$ pound-feet.

$M_{c2} = 35.75 \times 4 \times .839 \times 315 = 37{,}793$ pound-feet.

$M_{c3} = 33.25 \times 4 \times .839 \times 315 = 35{,}150$ pound-feet.

Total Moment, $M_t = 132{,}132$ pound-feet.

APPENDIX J—Page 12.



M_t = Total moment on pole.
L_g = Height of guy attachment from ground
L'_g = Distance of guy anchor from base of pole
T_g = Tension in guy wire

$$T_g = \frac{M_t}{L_g \text{ Sin } a}$$

$$\text{Sin } a = \frac{1}{\sqrt{1 + \left(\frac{L_g}{L'_g}\right)^2}}$$

M_t = 132,132 pound-feet.
L_g = 31.5 feet
L'_g = assume = 10.5 feet

$$\text{Sin } a = \frac{1}{\sqrt{1 + \left(\frac{31.5}{10.5}\right)^2}} = .3162$$

$$T_g = \frac{132{,}132}{31.5 \times .3162} = 13{,}266 \text{ pounds=tension in side guy.}$$

APPENDIX J—Page 13.

As the specified factor of safety for guys is three (3), there would be required to meet this tension a guy having an ultimate strength of not less than 39,798 pounds. This is too heavy a guy to be practicable, and the tension in the guy should be reduced by increasing the distance of the guy anchor from the base of the pole, that is, increasing L'_g. Assume L'_g can be made equal to L_g, or to thirty-one and five-tenths (31.5) feet, then—

$$\text{Sin } a = \frac{1}{\sqrt{1 + \left(\frac{31.5}{31.5}\right)^2}} = .707$$

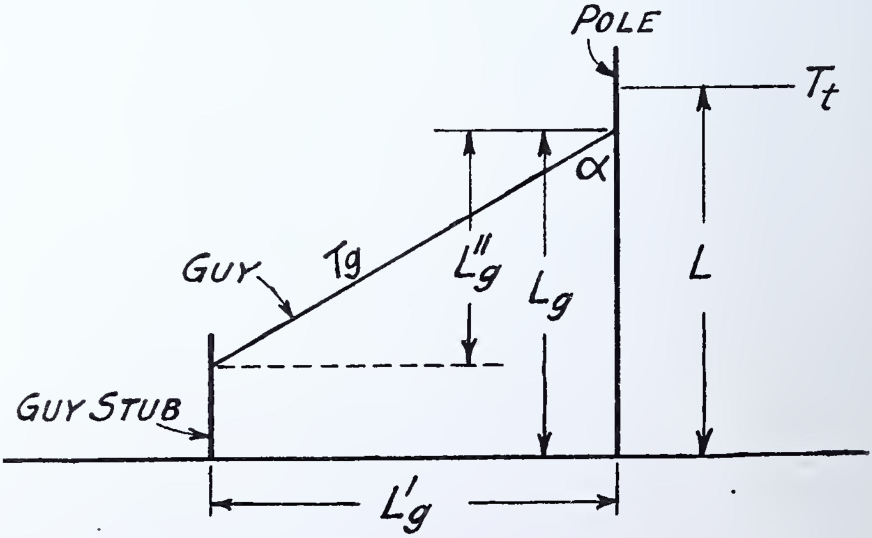
$$T_g = \frac{132{,}132}{31.5 \times .747} = 5{,}932 \text{ pounds}$$

$$= \text{tension in side guy.}$$

This would require a guy having an ultimate strength of 17,796 pounds, which could be obtained by using two Siemens-Martin seven-sixteenths (7/16) inch guy strands, each having an ultimate strength of 9,000 pounds.

Head Guying (For Poles "B" and "C.")

Total moment M_t = 485,085 pound-feet.
(From Page 148.)



$$T_g = \frac{M_t}{L_g \text{ Sin } a}$$

$$\text{Sin } a = \frac{1}{\sqrt{1 + \left(\frac{L''_g}{L'_g}\right)^2}}$$

$M_t = 485{,}085$ pound-feet.
$L_g = 31.5$ feet
$L'_g = 120$ feet
$L''_g = 25.5$ feet

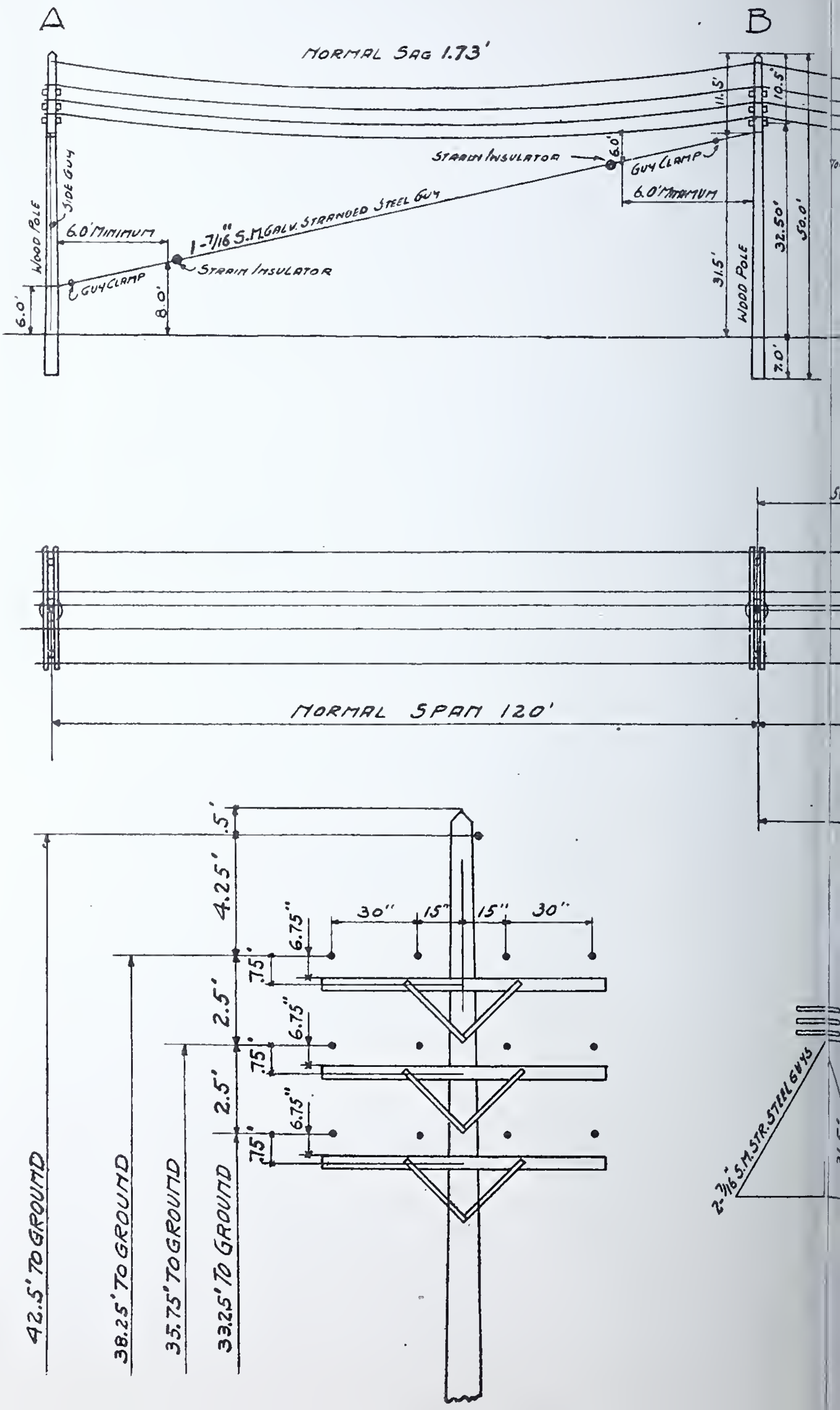
$$\text{Sin } a = \frac{1}{\sqrt{1 + \left(\frac{25.5}{120}\right)^2}} = .978$$

$$T_g \quad \frac{485{,}085}{31.5 \times .978} = 15{,}746 \text{ pounds}$$
$$= \text{tension in head guy.}$$

Under the unbalanced load due to the combined pull in one direction of all the conductors under maximum conditions of load, the pole, or, in this case its supporting guys, can be figured to withstand this unbalanced stress "without failure"; that is, the guys can be figured as stressed to their ultimate strength. There will be required, therefore, guys with ultimate strength of 15,746 pounds. To obtain this, there can be used two (2) seven-sixteenths (7/16) inch Siemens-Martin galvanized steel strands, having an ultimate strength of 9,000 pounds each; or, the unbalanced stress may be assumed to be distributed equally over the crossing poles and the next adjoining poles, as provided for in the last part of Paragraph 640 (b). If so assumed, one (1) head guy may be installed on each of the crossing poles "B" and "C," and also on each of the next adjoining poles, "A" and "D," each of these guys to be a seven-sixteenths (7/16) inch Siemens-Martin galvanized steel strand, having an ultimate strength of 9,000 pounds.

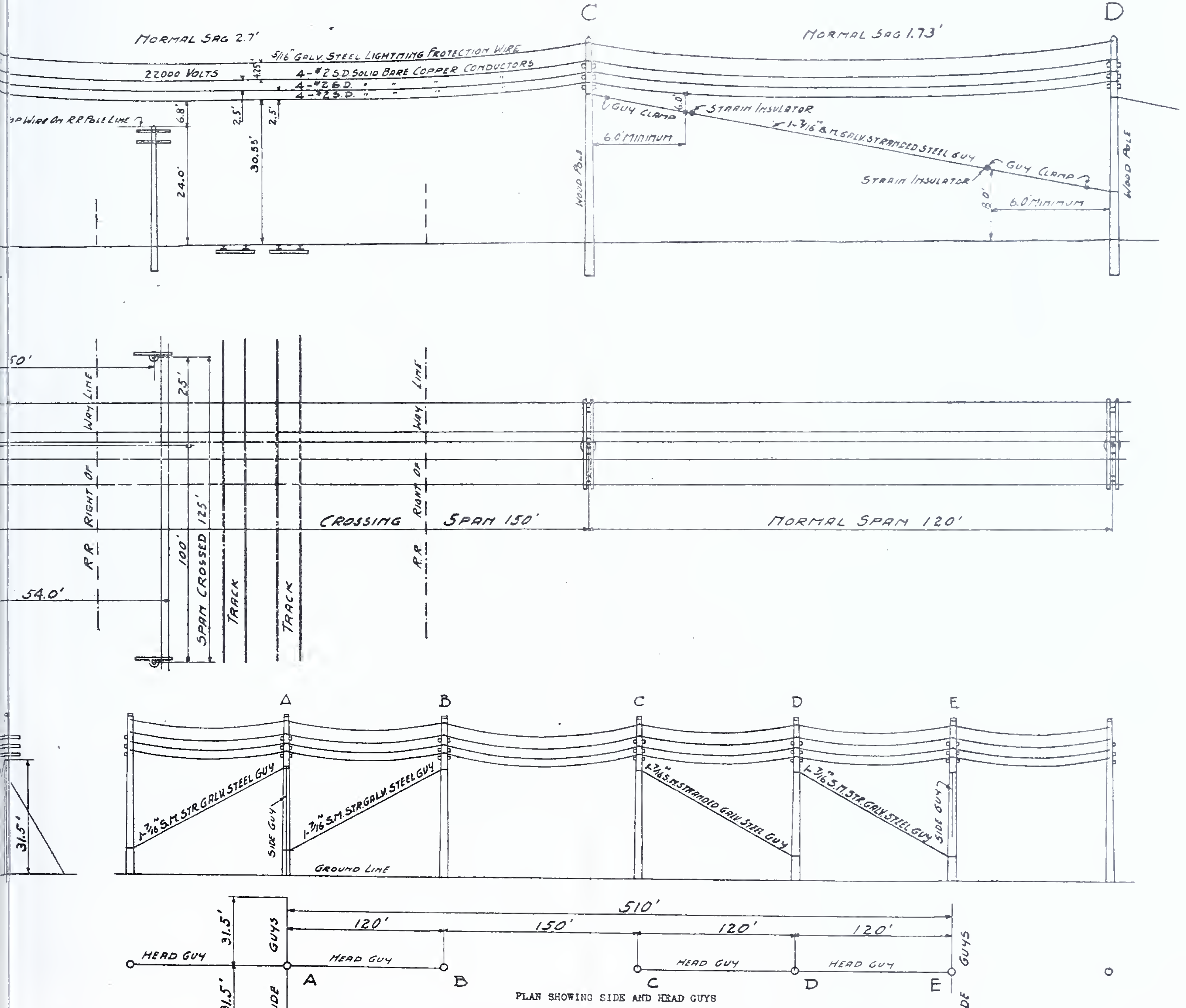
TYPICAL CROSSI

Poles "A" and "E" assumed t



OF POWER LINE OVER RAILROAD, WITH WOODEN POLE CONSTRUCTION, IN WHICH CROSSING POLES CAN NOT BE SIDE GUYED.

e the nearest poles at which it is practicable to install side guys, as provided for in paragraph 641.



PLAN SHOWING SIDE AND HEAD GUYS

NOTE: POLES "A" AND "E" TO BE SIDE GUYED. ENTIRE LINE BETWEEN POLES "A" AND "E" TO BE BUILT IN ACCORDANCE WITH SPECIFICATIONS, EXCEPT AS TO FACTOR OF SAFETY OF POLES. SEE PARAGRAPHS 640 AND 641.

APPENDIX K.

MISCELLANEOUS TABLES.

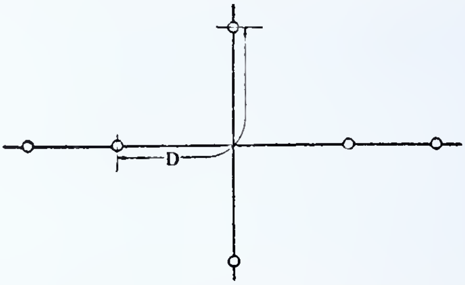
Minimum Vertical Clearances.

(Under Normal Conditions.)

Paragraphs 307 and 609.

BETWEEN CONDUCTORS OF THE CROSSING SPAN AND THE SPAN CROSSED.

NOTE:—In this table clearances are given for voltages ordinarily used and for various values of the distance "D". Distance "D" is the sum of the distances from the point of crossing to the nearest pole supporting the crossing span, and from the point of crossing to the nearest pole supporting the span crossed, as shown in sketch below.



Voltage of Circuit	Clearances for various Values of "D" in feet								
	0	10	20	30	40	50	60	70	80
2,300	4′ 0″	4′ 2″	4′ 4″	4′ 6″	4 8″	4 10″	5′ 0″	5′ 2″	5′ 4″
6,600	4′ 0″	4′ 2 ′	4′ 4″	4′ 6″	4′ 8″	4 10″	5′ 0″	5′ 2″	5′ 4″
13,,200	6′ 0″	6′ 0″	6′ 0″	6′ 0″	6′ 0″	6′ 0″	6′ 0″	6′ 0″	6′ 0″
22,000	6′ 0″	6′ 0″	6′ 0″	6′ 0″	6′ 0″	6′ 0″	6 0″	6′ 0″	6′ 0″
44,000	6′ 0″	6′ 0″	6′ 0″	6′ 0″	6′ 0″	6′ 0″	6′ 0″	6′ 0″	6′ 0″
66,000	6′ 7″	6′ 9″	6′ 11″	7′ 1″	7′ 3″	7′ 5″	7′ 7″	7′ 9″	7′ 11″
110,000	11′ 0″	11′ 2″	11′ 4″	11′ 6″	11′ 8″	11′ 10″	12′ 0″	12′ 2″	12′ 4″

Voltage of Circuit	Clearances for various Values of "D" in feet								
	90	100	150	200	250	300	350	400	450
2,300	5′ 6″	5′ 8″	6′ 6″	7′ 4″	8′ 2″	9′ 0″	9′ 10″	10′ 8″	11′ 6″
6,600	5′ 6″	5′ 8″	6′ 6″	7′ 4″	8′ 2″	9′ 0″	9′ 10″	10′ 8″	11′ 6″
13,200	6′ 0″	6′ 0″	6′ 6″	7′ 4″	8′ 2″	9′ 0″	9′ 10″	10′ 8″	11′ 6″
22,000	6′ 0″	6′ 0″	6′ 6″	7′ 4″	8′ 2″	9′ 0″	9′ 10″	10′ 8″	11′ 6″
44,000	6′ 0″	6′ 1″	6′ 11″	7′ 9″	8′ 7″	9′ 5″	10′ 3″	11′ 1″	11′ 11″
66,000	8′ 1″	8′ 3″	9′ 1″	9′ 1″	10″ 9′	11′ 7″	12′ 5″	13′ 3″	14′ 1″
110,000	12′ 6″	12′ 8″	13′ 6″	14′ 4″	15′ 2″	16′ 0″	16′ 10″	17′ 8″	18′ 6″

Voltage of Circuit	Clearances for various Values of "D" in feet								
	500	550	600	650	700	750	800	900	1000
2,300	12′ 4″	13′ 2″	14′ 0″	14′ 10″	15′ 8″	16′ 6″	17′ 4″	19′ 0″	20′ 8″
6,600	12′ 4″	13′ 2″	14′ 0″	14′ 10″	15′ 8″	16′ 6″	17′ 4″	19′ 0″	20′ 8″
13,200	12′ 4″	13′ 2″	14′ 0″	14′ 10″	15′ 8″	16′ 6″	17′ 4″	19′ 0″	20′ 8″
22,000	12′ 4″	13′ 2″	14′ 0″	14′ 10″	15′ 8″	16′ 6″	17′ 4″	19′ 0″	20′ 8″
44,000	12′ 9″	13′ 7″	14′ 5″	15′ 3″	16′ 1″	16′ 11″	17′ 9″	19′ 5″	21′ 1″
66,000	14′ 11″	15′ 9″	16′ 7″	17′ 5″	18′ 3″	19′ 1″	19′ 11″	21′ 7″	23′ 3″
110,000	19′ 4″	20′ 2″	21′ 0″	21′ 10″	22′ 8″	23′ 6″	24′ 4″	26′ 0 ′	27′ 8″

APPENDIX K--Page 3.

Minimum Vertical Clearances.

(Under Normal Conditions.)

Paragraph 608.

BETWEEN CONDUCTORS OF THE CROSSING SPAN AND THE TOP OF THE RAIL.

NOTE:—The clearances are given for various voltages and for various lengths of span.

Voltage of Conductors	CLEARANCES FOR VARIOUS LENGTHS OF SPAN IN FEET												
	150′ or less	200	250	300	350	400	450	500	600	700	800	900	1000
2,300.	27′ 0″	27′10″	28′8″	29′6″	30′ 4″	31′ 2″	32′0″	32′10″	34′6″	36′ 2″	37′10″	39′ 6″	41′ 2″
6.600, ...	27′ 0″	27′10″	28′8″	29′6″	30′ 4″	31′ 2″	32′ 0″	32′10″	34′6″	36′ 2″	37′10″	39′ 6″	41′ 2″
13,200, ...	27′ 8″	28′ 6″	29′4″	30′2″	31′ 0″	31′10″	32′ 8″	33′ 6″	35′2″	36′ 10″	38′ 6″	40′ 2″	41′10″
22,000, ...	28′ 6″	29′ 4″	30′2″	31′0″	31′ 10″	32′ 8″	33′ 6″	34′ 4″	36′0″	37′ 8″	39′ 4″	41′ 0″	42′ 8″
44.000, ...	29′ 9″	30′ 7″	31′5″	32′3″	33′ 1″	33′11″	34′ 9″	35′ 7″	37′3″	38′ 11″	40′ 7″	42′ 3″	43′11″
66,000, ...	31′ 0″	31′10″	32′8″	33′6″	34′ 4″	35′ 2″	36′ 0″	36′10″	38′6″	40′ 2″	41′10″	43′ 6″	45′ 2″
110,000, ...	33′ 0″	33′10″	34′8″	35′6″	36′ 4″	37′ 2″	38′ 0″	38′10″	40′6″	42′ 2″	43′10″	45′ 6″	47′ 2″

APPENDIX K—Page 4.

Minimum Clearances.

Paragraphs 311 and 613.

Between Any Power Conductor or Live Hardware, and Any Portion of the Supporting Structure.
(Insulator Pins Not Included).

Voltage.	Clearance.
2,300	3.00 inches
6,600	3.00 inches
13,200	4.55 inches
22,000	6.75 inches
44,000	12.25 inches
66,000	17.75 inches
110,000	28.75 inches

Minimum Clearances.

(Under Normal Conditions).

Paragraphs 309 and 611.

Between Conductors of One Line and Guy Wires of Another Line.

Voltage.	Clearance.
2,300	4 feet
6,600	4 feet
13,200	4 feet
22,000	4 feet
44,000	4 feet 5 inches
66,000	6 feet 7 inches
110,000	11 feet

Minimum Separation. (In Any Direction at the Point of Support.) Paragraphs 310 and 612. **For Power Conductors Carrying a Difference of Potential.** NOTE—The separations are given for various voltages, spans and sags.

MINIMUM SEPARATION OF CONDUCTORS SUPPORTED ON PIN TYPE INSULATORS

Span in Feet	100			200			300			400			500		
Sag in Feet	2	3	4	4	6	8	6	9	12	8	12	16	10	15	20
Voltage 2,300,......	1′ 0″	1′ 0″	1′ 0″	1′ 2″	1′ 4″	1′ 6″	1′ 9″	2′ 0″	2′ 3″	2′ 4″	2′ 8″	3′ 0″	2′ 11″	3′ 4″	3′ 9″
“ 6,600,......	1′ 0″	1′ 0″	1′ 0″	1′ 2″	1′ 4″	1′ 6″	1′ 9″	2′ 0″	2′ 3″	2′ 4″	2′ 8″	3′ 0″	2′ 11″	3′ 4″	3′ 9″
“ 13,200,......	1′ 8″	1′ 8″	1′ 8″	1′ 8″	1′ 8″	1′ 8″	1′ 9″	2′ 0″	2′ 3″	2′ 4″	2′ 8″	3′ 0″	2′ 11″	3′ 4″	3′ 9″
“ 22,000,......	2′ 6″	2′ 6″	2′ 6″	2′ 6″	2′ 6″	2′ 6″	2′ 6″	2′ 6″	2′ 6″	2′ 6″	2′ 8″	3′ 0″	2′ 11″	3′ 4″	3′ 9″
“ 44,000,......	3′ 9″	3′ 9″	3′ 9″	3′ 9″	3′ 9″	3′ 9″	3′ 9″	3′ 9″	3′ 9″	3′ 9″	3′ 9″	3′ 9″	3′ 9″	3′ 9″	3′ 9″
“ 66,000,......	5′ 0″	5′ 0″	5′ 0″	5′ 0″	5′ 0″	5′ 0″	5′ 0″	5″ 0′	5′ 0″	5′ 0″	5′ 0′	5′ 0″	5′ 0″	5′ 0″	5′ 0″
“ 110,000,......	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″

Span in Feet	600			700			800			900			1000		
Sag in Feet	12	18	24	14	21	28	16	24	32	18	27	36	20	30	40
Voltage 2,300,......	3′ 6″	4′ 0″	4′ 6″	4′ 1″	4′ 8″	5′ 3″	4′ 8″	5′ 4″	6′ 0″	5′ 3″	6′ 0″	6′ 9″	5′ 10″	6′ 8″	7′ 6″
“ 6,600,......	3′ 6″	4′ 0″	4′ 6″	4′ 1″	4′ 8″	5′ 3″	4′ 8″	5′ 4″	6′ 0″	5′ 3″	6′ 0″	6′ 9″	5′ 10″	6′ 8″	7′ 6″
“ 13,200,......	3′ 6″	4′ 0″	4′ 6″	4′ 1″	4′ 8″	5′ 3″	4′ 8″	5′ 4″	6′ 0″	5′ 3″	6′ 0″	6′ 9″	5′ 10″	6′ 8″	7′ 6″
“ 22,000,......	3′ 6″	4′ 0″	4′ 6″	4′ 1″	4′ 8″	5′ 3″	4′ 8″	5′ 4″	6′ 0″	5′ 3″	6′ 0″	6′ 9″	5′ 10″	6′ 8″	7′ 6″
“ 44,000,......	3′ 9″	4′ 0″	4′ 6″	4′ 1″	4′ 8″	5′ 3″	4′ 8″	5′ 4″	6′ 0″	5′ 3″	6′ 0″	6′ 9″	5′ 10″	6′ 8″	7′ 6″
“ 66,000,......	5′ 0″	5′ 0″	5′ 0″	5′ 0″	5′ 0″	5′ 3″	5′ 0″	5′ 4″	6′ 0″	5′ 3″	6′ 0″	6′ 9″	5′ 10″	6′ 8″	7′ 6″
“ 110,000,......	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 0″	7′ 6″

APPENDIX K—Page 6.

MINIMUM SEPARATION OF CONDUCTORS SUPPORTED ON DISC OR SUSPENSION TYPE INSULATORS

Span in Feet	100			200			300			400			500		
Sag in Feet	2	3	4	4	6	8	6	9	12	8	12	16	10	15	20
Voltage 22,000,....	3′ 1½″	3′ 1½″	3′ 1½″	3′ 1½″	3′ 1½″	3′ 1½″	3′ 1½″	3′ 1½″	3′ 1½″	3′ 1½″	3′ 4″	3′ 9″	3′ 7¾″	4′ 2″	4′ 8¼″
“ 44,000,....	4′ 8¼″	4′ 8¼″	4′ 8¼″	4′ 8¼″	4′ 8¼″	4′ 8¼″	4′ 8¼″	4′ 8¼″	4′ 8¼″	4′ 8¼″	4′ 8¼″	4′ 8¼″	4′ 8¼″	4′ 8¼″	4′ 8¼″
“ 66,000,....	6′ 3″	6′ 3″	6′ 3″	6′ 3″	6′ 3″	6′ 3″	6′ 3″	6′ 3″	6′ 3″	6′ 3″	6′ 3″	6′ 3″	6′ 3″	6′ 3″	6′ 3″
“ 110,000,....	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″

Span in Feet	600			700			800			900			1000		
Sag in Feet	12	18	24	14	21	28	16	24	32	18	27	36	20	30	40
Voltage 22,000,....	4′ 4½″	5′ 0″	5′ 7½″	5′ 1¼″	5′ 10″	6′ 6¾″	5′ 10″	6′ 8″	7′ 6″	6′ 6¾″	7′ 6″	8′ 5¼″	7′ 3½″	8′ 4″	9′ 4½″
“ 44,000,....	4′ 8¼″	5′ 0″	5′ 7½″	5′ 1¼″	5′ 10″	6′ 6¾″	5′ 10″	6′ 8″	7′ 6″	6′ 6¾″	7′ 6″	8′ 5¼″	7′ 3½″	8′ 4″	9′ 4½″
“ 66,000,....	6′ 3″	6′ 3″	6′ 3″	6′ 3″	6′ 3″	6′ 6¾″	6′ 3″	6′ 8″	7′ 6″	6′ 6¾″	7′ 6″	8′ 5¼″	7′ 3½″	8′ 4″	9′ 4½″
“ 110,000,....	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	8′ 9″	9′ 4½″

Wind and Ice Loads.

COPPER WIRE—SOLID—BARE.

SIZE A. W. G.	Ext. Diam. Inches	Area of Conductor Sq In.	Hard Drawn		Soft Drawn		Load per Lin. Foot Vertical		Load per Lin. Ft. Horizontal	Max. Load per Lin. Ft. Resultant	Angle of Resultant Load	EA	
			Ult. Tens.	All. Tens.	Ult. Tens.	All. Tens.	Dead	Dead + ½″ Ice	8.0 lb. per Sq. Ft. Cond. + ½″ Ice			Hard Drawn E =16,000,000	Soft Drawn E =12,000,000
0,000, ..	.460	.1662	8,320	4,160	5,660	2,830	.641	1.239	.973	1.575	38° 10′	2,659,000	1,994,000
000, ..	.410	.1318	6,600	3,300	4,480	2,240	.508	1.075	.940	1.427	44° 18′	2,109,000	1,582,000
00, ..	.365	.1045	5,220	2,610	3,560	1,780	.403	.942	.910	1.309	44° 3′	1,672,000	1,254,000
0, ..	.325	.0829	4,560	2,280	2,820	1,410	.319	.833	.884	1.214	46° 44′	1,325,000	995,000
1, ..	.289	.0657	3,740	1,870	2,240	1,120	.253	.774	.859	1.137	49° 6′	1,052,000	789,000
2, ..	.258	.0521	3,120	1,560	1,780	890	.201	.673	.839	1.075	51° 15′	834,000	626,000
3, ..	.229	.0413	2,480	1,240	1,400	700	.159	.613	.819	1.023	53° 10′	661,000	496,000
4, ..	.204	.0328	1,960	980	1,120	560	.126	.564	.802	.981	54° 52′	524,000	393,000
5, ..	.182	.0260	1,560	780	880	440	.100	.525	.788	.946	56° 20′	416,000	312,000
6, ..	.162	.0206	1,240	620	700	350	.079	.491	.775	.917	57° 50′	330,000	247,000

APPENDIX K—Page 8.

Wind and Ice Loads.

COPPER WIRE—SOLID—COVERED.

SIZE A. W. G.	Ext. Diam. Inches.	Area of Conductor Sq In.	Hard Drawn		Soft Drawn		Load per Lin. Foot Vertical		Load per Lin. Ft. Horizontal	Max. Load per Lin. Ft. Resultant	Angle of Resultant Load	EA	
			Ult. Tens.	All. Tens.	Ult. Tens.	All. Tens.	Dead	Dead + ½″ Ice	8.0 lb. per Sq. Ft. Cond. + ½″ Ice			Hard Drawn E =16,000,000	Soft Drawn E =12,000,000
0,000, ..	.460	.1662	8,320	4,160	5,660	2,830	.767	1.476	1.093	1.837	36° 34′	2,659,000	1,994,000
000, ..	.410	.1318	6,600	3,300	4,480	2,240	.629	1.309	1.062	1.686	39° 6′	2,109,000	1,582,000
00, ..	.365	.1045	5,220	2,610	3,560	1,780	.502	1.133	1.010	1.518	41° 45′	1,672,000	1,254,000
0, ..	.325	.0829	4,560	2,280	2,820	1,410	.407	1.029	1.000	1.434	44° 14′	1,326,000	995,000
1, ..	.289	.0657	3,740	1,870	2,240	1,120	.316	.909	.968	1.328	46° 50′	1,052,000	789,000
2, ..	.258	.0521	3,120	1,560	1,780	890	.260	.843	.958	1.276	48° 41′	834,000	626,000
3, ..	.229	.0413	2,480	1,240	1,400	700	.199	.763	.937	1.208	50° 50′	661,000	496,000
4, ..	.204	.0328	1,960	980	1,120	560	.164	.698	.906	1.143	52° 21′	524,000	393,000
5, ..	.182	.0260	1,560	780	880	440	.135	.660	.896	1.113	53° 37′	416,000	312,000
6, ..	.162	.0206	1,240	620	700	350	.112	.627	.885	1.084	54° 41′	330,000	247,000

Wind and Ice Loads.

COPPER WIRE—STRANDED—BARE.

SIZE A. W. G.	Ext. Diam. Inches	Area of Conductor Sq. In.	Hard Drawn		Soft Drawn		Load per Lin. Foot Vertical		Load per Lin. Ft. Horizontal	Max. Load per Lin. Ft. Resultant	Angle of Resultant Load	EA	
			Ult. Tens.	All. Tens.	Ult. Tens.	All. Tens.	Dead	Dead + ½" Ice	8.0 lb. per Sq. Ft. Cond. + ½" Ice			Hard Drawn E =16,000,000	Soft Drawn E =12,000,000
500,000, .	.814	.3924	23,540	11,770	13,340	6,670	1.540	2.357	1.209	2.649	27° 8′	6,278,000	4,709,000
450,000, ..	.772	.3535	21,200	10,600	12,020	6,010	1.390	2.181	1.182	2.481	28°30′	5,656,000	4.242,000
400,000, ..	.728	.3141	18,850	9,420	10,680	5,340	1.240	2.004	1.152	2.311	29°52′	5,026,000	3,769,000
350,000, ..	.681	.2750	16,500	8,250	9,340	4,670	1.080	1.815	1.121	2.133	31°42′	4,400,000	3,300,000
300,000, ..	.630	.2354	14,120	7,000	8,020	4,010	.926	1.629	1.087	1.958	33°40′	3,770,000	2,825,000
250.000, ..	.575	.1963	11,780	5,890	6,680	3,340	.772	1.441	1.050	1.783	36° 3′	3,141,000	2,356,000
0,000, ..	.528	.1662	9,980	4,990	5,660	2,830	.653	1.292	1.019	1.645	38°14′	2,659,000	1,994,000
000, ..	.470	.1318	7,900	3,950	4,480	2,240	.518	1.121	.980	1.489	41° 6′	2,109,000	1,582,000
00, ..	.418	.1045	6,280	3,140	3,560	1,780	.411	.982	.945	1.363	43°52′	1,672,000	1,254,000
0, ..	.373	.0829	4,980	2,490	2,820	1,410	.326	.870	.915	1.262	46°28′	1,326,000	995,000
1, ..	.332	.0657	3,940	1,970	2,240	1,120	.258	.776	.888	1.179	48°51′	1,051,000	788,000
2, ..	.292	.0521	3,120	1,560	1,780	890	.205	.698	.861	1.108	50° 0′	834,000	625,000
3, ..	.260	.0413	2,480	1,240	1,400	700	.163	.636	.840	1.054	52°51′	661,000	496,000
4, ..	.232	.0328	1,960	980	1,120	560	.129	.584	.821	1.008	54°34′	525,000	394,000
5, ..	.206	.0260	1,560	780	880	440	.102	.541	.804	.969	55°57′	416,000	312.000
6, ..	.184	.0206	1,240	620	700	350	.081	.506	.789	.938	57°20′	330,000	247,000

Wind and Ice Loads.

COPPER WIRE—STRANDED—COVERED.

SIZE A. W. G.	Ext. Diam. Inches	Area of Conductor Sq. In	Hard Drawn		Soft Drawn		Load per Lin. Foot Vertical		Load per Lin. Ft. Horizontal	Max. Load per Lin. Ft. Resultant	Angle of Resultant Load	EA	
			Ult. Tens.	Ult. Tens.	Ult. Tens.	Ult. Tens.	Dead	Dead + ½″ Ice	8.0 lb. per Sq. Ft. Cond. + ½″ Ice			Hard Drawn E =16,000,000	Soft Drawn E =12,000,000
500,000, ..	1.108	.3924	23,530	11,770	13,340	6,670	1.894	2.894	1.405	3.217	25° 50′	6,278,000	4,709,000
450,000, ..	1.070	.3535	21,200	10,600	12,020	6,010	1.724	2.701	1.380	3.032	27° 3′	5,656,000	4,242,000
400,000, ..	1,020	.3141	18,840	9,420	10,680	5,340	1.553	2.498	1.347	2.838	28° 18′	5,026,000	3,769,000
350,000, ..	.978	.2750	16,500	8,250	9,370	4,670	1.345	2.264	1.319	2.619	30° 13′	4,400,000	3,300,000
300,000, ..	.930	.2354	14,120	7,060	8,020	4,010	1.174	2.064	1.287	2.432	31° 58′	3,770,000	2,825,000
250,000, ..	.862	.1963	11,780	5,890	6,680	3,340	.985	1.832	1.241	2.217	34° 7′	3,141,000	2,356,000
0,000, ..	.785	.1662	9,980	4,990	5,660	2,830	.800	1.599	1.190	1.993	36° 38′	2,659,000	1,994,000
000, ..	.728	.1318	7,800	3,950	4,480	2,240	.653	1.417	1.152	1.826	39° 6′	2,109.000	1,582,000
00, ..	.662	.1045	6,280	3,140	3,560	1,780	.522	1.245	1.108	1.666	41° 39′	1,672,000	1,254,000
0, ..	.605	.0829	4,980	2,490	2,820	1,410	.424	1.111	1.070	1.542	43° 54′	1,326,000	995,000
1, ..	.518	.0657	3,940	1,970	2,240	1,120	.328	.961	1.012	1.395	47° 27′	1,051,000	788,000
2, ..	.440	.0521	3,120	1,560	1,780	890	.270	.855	.960	1.285	48° 21′	834,000	625,000
3, ..	.408	.0413	2,480	1,240	1,400	700	.206	.771	.939	1.214	50° 37′	661,000	496,000
4, ..	.379	.0328	1,960	980	1,120	560	.170	.717	.919	1.165	52° 5′	525,000	394,000
5, ..	.351	.0260	1,560	780	880	440	.140	.669	.902	1.122	53° 24′	416,000	312,000
6, ..	.327	.0206	1,240	620	700	350	.115	.629	.885	1.086	54° 36′	330,000	247,000

Wind and Ice Loads.
ALUMINUM WIRE—STRANDED—BARE.

Copper Equiv. C. M. or A. W. G.	Size C. M.	Ext. Diam. Inches	Area of Conductor Sq. In.	Ult. Tens.	All Tens.	Load per Lin. Foot Vertical		Load per Lin. Ft. Horizontal	Max. Load per Lin. Ft. Resultant	Angle of Resultant Load	EA
						Dead	Dead + ½" Ice	8.0 lb. per Sq. Ft. Cond. + ½" Ice			E=9,000,000
500,000, ..	795,000	1.0255	.6240	14,360	7,180	.732	1.681	1.350	2.156	38° 4′	5,616,000
450,000, ..	715,500	.9737	.5620	12,920	6,460	.658	1.575	1.316	2.052	39° 52′	5,058,000
400,000, ..	636,000	.9184	.5000	11,500	5,750	.585	1.467	1.279	1.946	41° 4′	4,500,000
350,000, ..	556,500	.8555	.4370	10,060	5,030	.512	1.355	1.237	1.835	42° 24′	3,933,000
314.500, ..	500,000	.8115	.3926	9,040	4,520	.460	1.276	1.208	1.757	43° 26′	3.533,000
300,000, ..	477,000	.7925	.3745	8,620	4,310	.439	1.243	1.195	1.724	43° 50′	3,370,000
250,000, ..	397,500	.7235	.3120	7,180	3,590	.365	1.126	1.149	1.608	45° 39′	2.808,000
0,000, ..	336,420	.6570	.2640	6,080	3,040	.310	1.030	1.105	1.511	47° 53′	2,376,000
188,600, ..	300.000	.6280	.2356	5,420	2,710	.276	.978	1.085	1.461	48° 0′	2,120,000
000, ..	266,800	.5859	.2095	4,820	2,410	.246	.921	1.057	1.402	48° 55′	1.885,000
00, ..	211,950	.5220	.1665	3,840	1,920	.195	.831	1.015	1.312	50° 40′	1,498,000
0, ..	167,800	.4644	.1318	3,040	1,520	.155	.755	.976	1.234	52° 19′	1,860,000
1, ..	133,220	.4140	.1045	2,400	1,200	.123	.692	.943	1.170	53° 46′	940,000
2, ..	105 530	.3684	.0829	1,900	950	.097	.637	.912	1.113	55° 6′	746,000
3, ..	83,642	.3279	.0657	1,520	760	.077	.592	.885	1.066	56° 16′	591,000

Wind and Ice Loads.

STEEL WIRE—STRANDED—GALVANIZED.

SIZE	Diam. Inches	Area Sq. In.	Siemens-Martin		High Tension		Load per Lin. Foot Vertical		Load per Lin. Ft. Horizontal	Max. Load per Lin. Ft. Resultant	Angle of Resultant Load	EA
			Ult. Tens.	All Tens.	Ult. Tens.	All Tens.	Dead	Dead ½″ Ice	8.0 lb. per Sq. Ft. Cond. ½″ Ice			E=29,000,000
5/8, ...	.6250	.2356	19,000	9,500	25,000	12,500	.821	1.520	1.083	1.867	35° 28′	6,832,000
9/16, ...	.5625	.1922	14,500	7,250	21,100	10,550	.668	1.329	1.042	1.689	38° 2′	5,574,000
1/2, ...	.5000	.1443	11,000	5,500	18,000	9,000	.510	1.132	.999	1.510	41° 28′	4,185,000
7/16, ...	.4375	.1204	9,000	4,500	15,000	7,500	.415	.998	.958	1.383	43° 25′	3,492,000
3/8, ...	.3750	.0832	6,800	3,400	10,500	5,250	.295	.839	.917	1.243	47° 52′	2,413,000
5/16, ...	.3125	.0606	4,860	2,430	8,100	4,050	.210	.715	.875	1.130	50° 43′	1,757,000

APPENDIX L

ALLOWABLE NUMBER OF No. 4 SOLID COPPER, TRIPLE BRAIDED, WEATHER-PROOF WIRES TO BE CARRIED BY CHESTNUT POLES.

Conforming to Specifications given in Appendix "B."

Loading—½ inch Ice.
4 Lbs. per Sq. Ft. Wind Pressure.

Allowable Unit Fiber Stress—2500 Lbs. per Sq. In.

NOTE:—"Special" pole is a Class "A" pole; 5 feet longer than the specified length, cut off 5 feet at the top. The use of 6-pin cross-arms is assumed unless otherwise indicated.

THIS TABLE FOR USE WITH SECTION II ONLY.

LENGTH OF POLE	Length of Span	ALLOWABLE NUMBER OF WIRES			
		Special pole	Class "A" pole	Class "B" pole	Class "C" pole
30, ...	100	†*24	†*24	†*24	†22
	125	†*24	†*24	†23	17
	150	†*24	†*24	†19	14
	200	†*24	†19	14	10
35, ...	100	†*40	†*40	†32	24
	125	†37	†33	28	19
	150	†31	29	22	15
	200	24	20	16	11
40, ...	100	†49	42	39	30
	125	42	35	30	23
	150	36	28	24	18
	200	25	20	17	13
45, ...	100	66	50	46	32
	125	47	37	34	25
	150	37	30	28	20
	200	26	21	20	15

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*Limited by clearance.
†Requires 8-pin cross-arms.

(Table continued on page 168).

APPENDIX L—Page 2.

LENGTH OF POLE	Length of Span.	ALLOWABLE NUMBER OF WIRES			
		Special pole	Class "A" pole	Class "B" pole	Class "C" pole
50, ...	100	66	52	48	35
	125	49	39	36	27
	150	39	31	29	22
	200	28	23	21	16
55, ...	100	70	56	52	38
	125	52	42	39	30
	150	41	34	32	24
	200	29	24	23	18
60, ...	100	74	60	56	....
	125	55	45	43	....
	150	44	36	34	....
	200	31	26	25	....
65, ...	100	82	64	60	....
	125	58	48	45	....
	150	46	39	37	....
	200	33	28	27	....
70, ...	100	82	68	64	....
	125	61	51	48	....
	150	49	41	39	....
	200	35	30	28	....
75, ...	100	93	73	68	....
	125	69	55	52	....
	150	55	44	42	....
	200	39	32	30	....
80, ...	100	97	82	77	....
	125	72	62	59	....
	150	58	50	47	....
	200	41	36	34	....

APPENDIX L—Page 3.

ALLOWABLE NUMBER OF No. 4 SOLID COPPER, TRIPLE BRAIDED, WEATHER-PROOF WIRES TO BE CARRIED BY WESTERN CEDAR POLES.

Conforming to Specifications given in Appendix "B."

Loading—½ inch Ice.
4 Lbs. per Sq. Ft. Wind Pressure.

Allowable Unit Fiber Stress—2600 Lbs. per Sq. In.

NOTE:—"Special" pole is a Class "A" pole; 5 feet longer than the specified length, cut off 5 feet at the top. The use of 6-pin cross-arms is assumed unless otherwise indicated.

THIS TABLE FOR USE WITH SECTION II ONLY.

LENGTH OF POLE	Length of Span	ALLOWABLE NUMBER OF WIRES			
		Special pole	Class "A" pole	Class "B" pole	Class "C" pole
30, ...	100	†*24	†*24	†*24	16
	125	†*24	†*24	†19	12
	150	†*24	†20	16	10
	200	†19	15	11	7
35, ...	100	†*40	†33	24	16
	125	†32	28	19	12
	150	29	22	15	10
	200	20	16	11	7
40, ...	100	42	39	24	16
	125	35	29	19	13
	150	28	24	15	10
	200	20	17	11	8
45, ...	100	45	38	25	17
	125	34	29	19	13
	150	27	23	16	11
	200	20	17	11	8

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*Limited by clearance.
†Requires 8-pin cross-arms.

(Table continued on page 170).

APPENDIX L—Page 4.

LENGTH OF POLE	Length of Span.	ALLOWABLE NUMBER OF WIRES			
		Special pole	Class "A" pole	Class "B" pole	Class "C" pole
50, ...	100	44	37	25	18
	125	33	29	19	14
	150	27	23	16	11
	200	19	17	12	8
55, ...	100	47	38	26	19
	125	36	29	20	15
	150	29	24	16	12
	200	21	17	12	9
60, ...	100	48	41	27	18
	125	36	32	21	14
	150	30	26	17	12
	200	21	19	13	8
65, ...	100	48	42	28	19
	125	37	33	22	15
	150	30	27	18	12
	200	22	19	13	9

APPENDIX L—Page 5.

ALLOWABLE NUMBER OF No. 4 SOLID COPPER, TRIPLE BRAIDED, WEATHER-PROOF WIRES TO BE CARRIED BY EASTERN WHITE CEDAR POLES.

Conforming to Specifications given in Appendix "B."

Loading—½ inch Ice.
4 Lbs. per Sq. Ft. Wind Pressure.

Allowable Unit Fiber Stress—1500 Lbs. per Sq. In.

NOTE:—"Special" pole is a Class "A" pole; 5 feet longer than the specified length, cut off 5 feet at the top. The use of 6-pin cross-arms is assumed unless otherwise indicated.

THIS TABLE FOR USE WITH SECTION II ONLY.

LENGTH OF POLE	Length of Span	ALLOWABLE NUMBER OF WIRES			
		Special pole	Class "A" pole	Class "B" pole	Class "C" pole
30, ...	100	†*24	†23	17	13
	125	†23	18	13	10
	150	†19	15	11	8
	200	14	11	8	6
35, ...	100	†32	25	16	13
	125	27	19	12	10
	150	21	16	10	8
	200	15	11	7	6
40, ...	100	36	29	21	16
	125	27	22	16	12
	150	22	18	13	10
	200	16	13	9	7
45, ...	100	37	30	24	18
	125	28	23	19	14
	150	23	19	15	11
	200	17	14	11	8

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†Requires 8-pin cross-arms.
*Limited by clearance.

(Table continued on page 172.)

APPENDIX L—Page 5.

LENGTH OF POLE	Length of Span.	ALLOWABLE NUMBER OF WIRES			
		Special pole	Class "A" pole	Class "B" pole	Class "C" pole
50, ...	100	38	31	25	19
	125	30	24	20	15
	150	24	20	16	12
	200	17	14	12	9
55, ...	100	40	33	27	21
	125	31	26	21	16
	150	25	21	17	13
	200	18	15	13	10
60, ...	100	42	35	30	23
	125	33	28	23	18
	150	27	22	19	15
	200	19	16	14	11